Relation of residue biomass after defoliation to regrowth dry matter, WSC and grain yield of winter wheat

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Introduction

The importance of defoliation height on final yield in dual-purpose wheat is inconsistent. In one study no difference in final wheat yield following a severe grazing at 2 cm compared to light grazing at 6 cm was found (Dann *et al.* 1983). In contrast, clipping at 3 cm above ground level significantly reduced grain yield compared to 7 cm (Arzadun *et al.* 2006). An explanation for these inconsistent results may be an underestimation of the value of the remaining biomass and its role in the regrowth process (Fulkerson and Donaghy 2001).

In this study, the percentage of residue biomass remaining after defoliation was considered when examining the effect of defoliation height on dry matter accumulation and water-soluble carbohydrate (WSC) during wheat regrowth on the Loess plateau, China.

Methods

The experimental trial was established at Qingyang Loess Plateau Research Station of Lanzhou University (35°40 N, 107°52 E; altitude 1298 m a.s.l.) in Gansu Province of China. Agriculture in this area is rain-fed with summer-dominant rainfall. Wheat (*Triticum aestivum*) was sown on 20 September 2010 (cv. Longyu 216). Four treatments with an uncut control and 3 defoliation treatments (Light defoliation, Moderate defoliation and Severe defoliation) were imposed at tillering (7 April 2011) with 81%, 45% and 0% of the total biomass left for regrowth, respectively. Treatments were arranged in a randomised complete block design with 4 replicates; the plot size was 3 m by 3 m.

Dry matter was compared between the treatments at 3 crop stages (booting, anthesis and maturity) by sampling 3 rows (1 m×0.15 m×3) from the centre of each plot. At crop maturity, total grain yield and yield components (spike number per m^2, grain number per spike and kernel weight) were measured. Water-soluble carbohydrate (WSC) within the plant at booting and anthesis were analysed by the anthrone method (Yemm and Willis 1954).

Results and Discussion

DM dynamic of regrowth

Following defoliation, the dry matter accumulation at booting of the light defoliation treatment was 17% higher than the uncut control, while both the moderate and severe defoliation produced less biomass than the uncut control, 26% and 58% (P<0.05), respectively. At anthesis, this relationship remained unchanged, the light defoliation treatment had accumulated 13% more biomass and the moderate and severe defoliation treatments accumulated 8% and 42% (P<0.05) less biomass than the uncut control (Table 1).

WSC concentration and storage at booting and anthesis

During regrowth, there was no significant difference between defoliation treatments in the WSC concentration at booting; at anthesis, a similar trend occurred apart from the severe defoliation treatment that had an increased WSC concentration. With respect to WSC storage (total DM multiplied by the WSC concentration), the light defoliation increased the WSC storage as a result of the increased DM production at both booting and anthesis. For the moderate and severe defoliation, the WSC storage at booting was reduced by 12% (P>0.05) and 55% (P<0.05), but at anthesis, the reduction was less (8% and 14%, respectively), as the DM accumulation had caught up and WSC concentration was slightly increased.

Table 1. Regrowth of DM at booting and anthesis under different defoliation treatments (mean±se).

Defoliation intensity	Residue DM (t/ha)	Booting (t/ha)	Anthesis (t/ha)
Uncut control	1.01 ± 0.16	3.13 ± 0.37	5.45 ± 0.27
Light	0.82 ± 0.04	3.66 ± 0.60	6.17 ± 0.27
Moderate	0.55 ± 0.06	2.31 ± 0.30	5.02 ± 0.24
Severe	0	1.30 ± 0.20	3.16 ± 0.07
LSD(P=0.05)	0.27	1.23	0.70

Table 2. Water-soluble carbohydrate (WSC) concentration (% DM) and storage (t/ha) under different defoliation treatments (mean±se)

Defoliation intensity	Booting		Anthesis	
	WSC concentration (% DM)	Stored WSC (t/ha)	WSC concentration (% DM)	Stored WSC (t/ha)
Uncut control	2.38 ± 0.08	7.45 ± 0.41	2.12 ± 0.05	11.55 ± 0.38
Light	2.73 ± 0.07	9.99 ± 1.01	2.03 ± 0.09	12.52 ± 0.54
Moderate	2.83 ± 0.12	6.54 ± 0.09	2.13 ± 0.42	10.69 ± 0.72
Severe	2.60 ± 0.06	3.38 ± 0.18	3.14 ± 0.07	9.92 ± 1.37
LSD(*P*=0.05)	0.36	1.68	0.30	2.51

Table 3. Grain yield and yield components under different defoliation treatments (mean±se)

Defoliation intensity	Grain yield (t/ha)	Spike number/m^2	Grain number/ spike	Kernel (g)
Uncut control	3.2 ± 0.2	393 ± 10	25 ± 1	32.7 ± 0.6
Light	3.2 ± 0.5	398 ± 38	24 ± 2	33.2 ± 0.9
Moderate	2.4 ± 0.3	334 ± 15	25 ± 5	29.4 ± 0.1
Severe	2.2 ± 0.1	273 ± 36	24 ± 2	34.6 ± 0.4
LSD(*P*=0.05)	0.9	91	9	4.5

Grain yield and yield components

The yield penalty was increased with the increased removal of biomass at defoliation (Table 3). Light defoliation produced the same grain yield as the uncut control. The moderate defoliation produced 25% less grain, but not significantly different to the uncut control and the severe defoliation treatment produced 31% less grain and was significantly less than the uncut control. As to the yield components, the more intense defoliation reduced tiller number more, but there was little impact on the grain number and kernel size, so spike number per m^2 was the most sensitive yield component that responded to the defoliation treatment (Table 3).

Conclusions

Selecting a defoliation height that allowed more than 45% of the biomass to remain in the field maintained a high concentration of carbohydrate within the wheat crop and prevented a significant grain yield loss when used as dual-purpose on the Loess plateau, China.

References

Arzadun MJ, Arroquy JI, Laborde HE, Brevedan RE (2006) Effect of planting date, clipping height, and cultivar on forage and grain yield of winter wheat in Argentinean Pampas. *Agronomy Journal* **98**, 1274-1279.

Dann PR, Axelsen A, Dear BS, Williams ER, Edwards CBH (1983) Herbage, grain and animal production from winter-grazed cereal crops. *Australian Journal of Experimental Agriculture* **23**, 154-161.

Fulkerson W, Donaghy D (2001) Plant-soluble carbohydrate reserves and senescence - key criteria for developing an effective grazing management system for ryegrass-based pastures: a review. *Animal Production Science* **41**, 261-275.

Yemm E, Willis A (1954) The estimation of carbohydrates in plant extracts by anthrone. *Biochemical Journal* **57**, 508.