Cultivar Difference in Within-Spike N remobilization in CWRS Wheat

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Abstract

The objective of the present study was to compare four new CWRS wheat cultivars with two older cultivars, Neepawa and Marquis, in terms of spike dry matter and nitrogen accumulation and within-spike partitioning. Results showed that new cultivars had significantly higher kernel mass and N content per spike than old cultivars, which were mainly attributed to their higher accumulation rates, instead of accumulation durations. N remobilisation from glumes occurred during the linear phase of grain filling and new cultivars started remobilising N earlier and had a higher rates than old cultivars. N remobilisation of rachis started later and the rate was smaller than glumes. New cultivars had higher total N remobilisation and maximum remobilisation rate from rachis than old ones. It seems that cultivars with large sink size had a high rate of accumulation and were able to remobilise more carbohydrates and N into the grains before maturity. Cultivars with small sink size had both relatively low accumulation rate and remobilisation rate. Although visual observations showed that Marquis and Neepawa had 1-3 days longer maturity than new cultivars, grain accumulation of carbohydrates and N was minimal during these days because of the severe water stress and/or heat stress.

Introduction

In the past decades, the increase in grain yield in wheat is often associated with a decrease in grain protein concentration (GPC) in most of the regions of the world. This approach is not acceptable for some high quality wheat classes, such as Canada Western Red Spring (CWRS), in which class the GPC requirements for registration are higher than in some other wheat classes, such as the Canada Prairie Spring wheat. In a three-year field study, Wang et al. (2002) observed that some high-yielding and high-GPC CWRS cultivars had significantly increased spike yield by means of greater individual kernel weight and/or more kernels per spike, while the number of spikes per plant did not change or was reduced. The increase in the spike sink size of these new CWRS cultivars might be associated with the increase in the demand and/or storage capacity for both carbohydrates and N.

Most of the grain N are from assimilation before anthesis and are remobilized from various vegetative parts during grain filling. Nitrogen partitioning was reported from glumes and rachis. If cultivars with larger spike sink size have greater demand and/or greater storage capacity of grains for N, accumulations of grains and depletions (remobilizations) of glumes and rachis in N should be greater compared to cultivars with smaller spike sink size. The objective of this study was to compare new high-yielding CWRS wheat cultivars (larger spikes) with older cultivars (smaller spikes) in kernel N accumulation and within-spike N remobilizations during the period of grain filling.

Materials and Methods

Two old (Marquis and Neepawa) and four new (AC Barrie, AC Cadillac, AC Elsa and AC Intrepid) high-quality CWRS cultivars were used in this study. A field test was conducted on a Swinton loam soil (Orthic Brown Chernozem) near Swift Current, SK, from 1998 to 2000, in a randomized complete block design with four replications. Trials were grown on summerfallow. Each plot was 16 rows, 3 m long, 0.23 m apart, with four rows of winter wheat were seeded between plots (not in 1999). Mono-ammonium phosphate and ammonium sulphate were broadcasted each year before seeding with targets of 112 kg ha-1 available N and 67 kg ha^{-1} available P based on soil tests at the end of October in each year prior to spring seeding. The seeding rate was 250 seeds per square metre which was adjusted according to a germination test done prior to seeding. Seeding dates were April 28, 1998, May 26, 1999, and May 9, 2000. There were no irrigations except that 48 mm of water was sprinkled on July 16, 1998. Five spikes were randomly taken from each plot every 2-4 d after anthesis. Samples were oven dried at 60 oC for a minimum of 72 h. Kernel, glumes and rachis were separated by hand and weighed. Samples were ground through a 2-mm screen with a Wiley mill. Kjeldahl N using the indophenol procedure was determined.

Results and Discussion

For the three years of this study the mean growing-season (May-July) daily temperature was 14.6 ^{o}C, slightly below the long-term average (1900-2000) of 15.0 oC. The mean precipitation during growing-season was 233 mm, which was higher than the average of 196 mm during 1991-1996, and the long-term average of 168 mm.

On average, new cultivars had 34.3% and 5.9% higher grain yield than Marquis and Neepawa, respectively. New cultivars, as a group, had significantly higher N content per spikes than old cultivars, which were mainly attributed to their higher accumulation rates, instead of accumulation durations (Fig. 1). Although Marquis tended to have longer duration, it had the lowest accumulation rates.

The change patterns of dry matter during grain filling for glumes and rachis are similar among different groups (Fig. 2 and 3). New cultivars tended to have higher glume dry matter and Marquis tended to have higher rachis dry matter. Marquis had significantly higher N concentration in both glumes and rachis during the whole period of grain filling in each year and its reduction of N from the beginning of grain filling to maturity was lower than new cultivars and Neepawa (Fig 4 and 5). This resulted in cultivar differences in total N remobilization during grain filling from both glumes and rachis. On average over three years, N remobilizations from glumes were 3.49 mg N spike-1 for new cultivar group, 2.43 mg N spike-1 for Neepawa and 2.45 mg N spike-1 for Marquis. N remobilizations from rachis were 0.52 mg for new cultivar group, 0.41 mg N spike-1 for Neepawa and 0.46 mg N spike-1 for Marquis. Assume all N was remobilized to the grain, the contribution of remobilized N to grain N from glumes and rachis was 14.1% for new cultivar group, 11.3% for Neepawa and 13.1% for Marquis.

In conclusion, large spike new CWRS cultivars had significantly more within-spike N remobilization compared to small spike old cultivars. It seems that a large sink size is competitive for accumulating in both carbohydrates and N.

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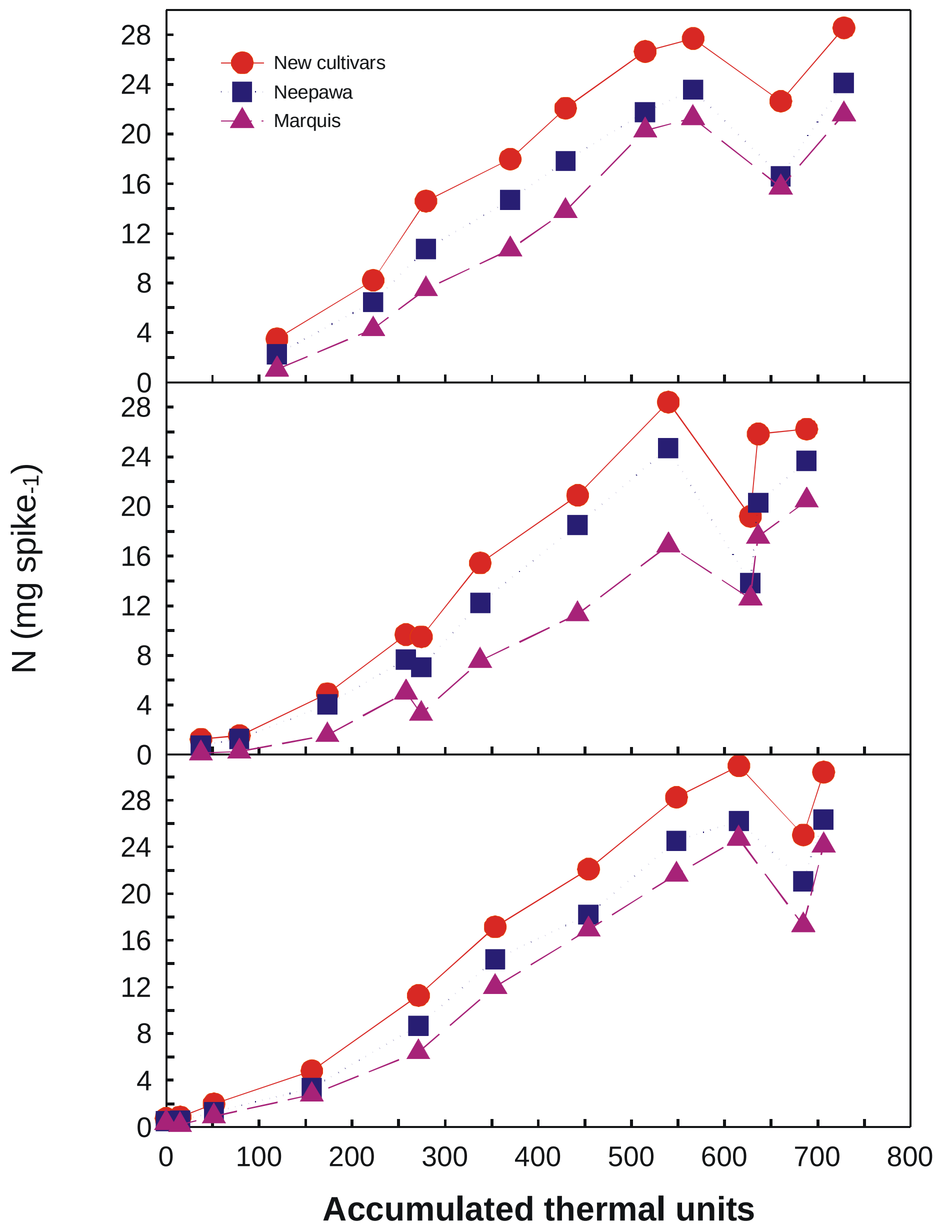

Fig. 1. Changes of kernel N per spike.

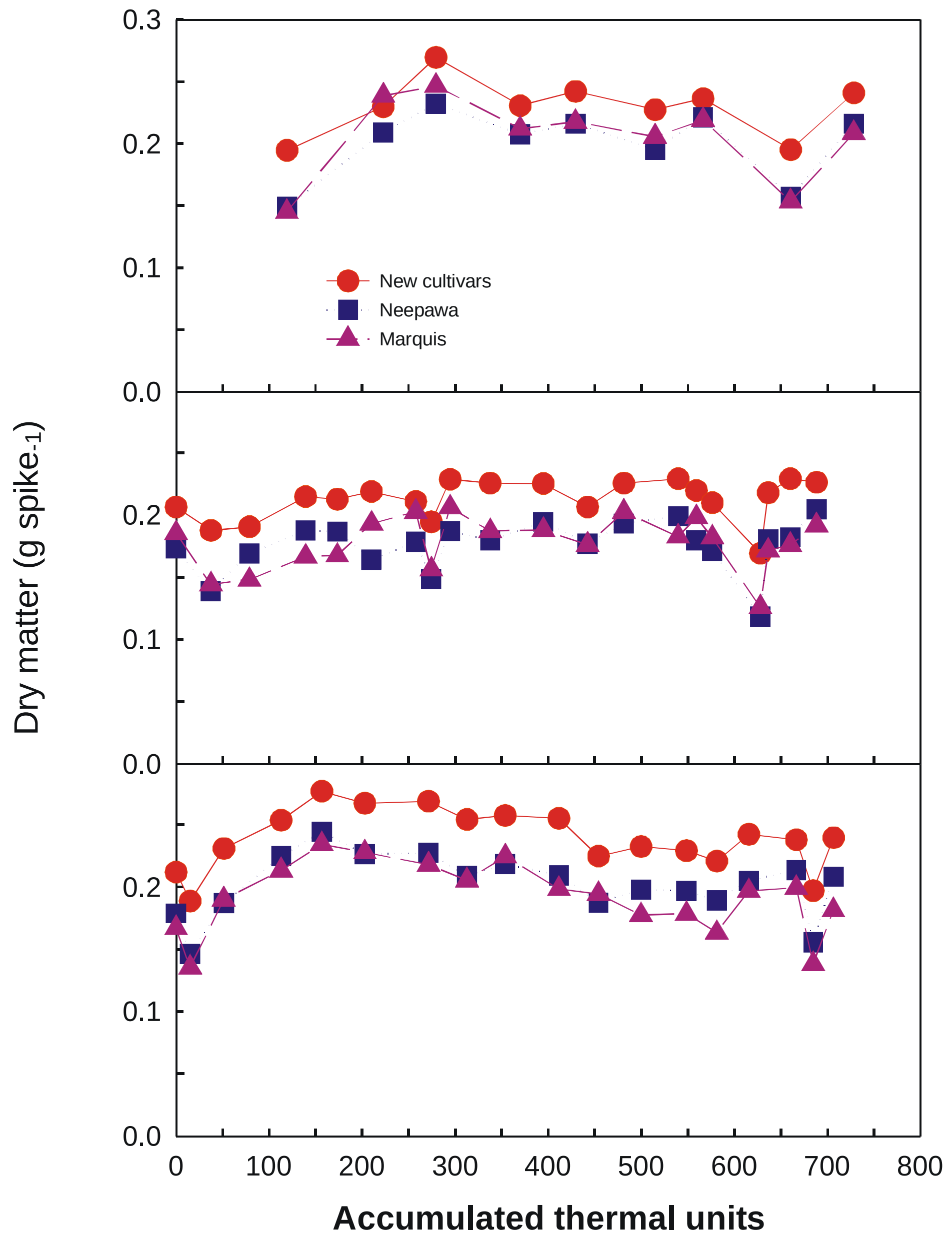

Fig. 2. Changes of glume dry matter per spike.

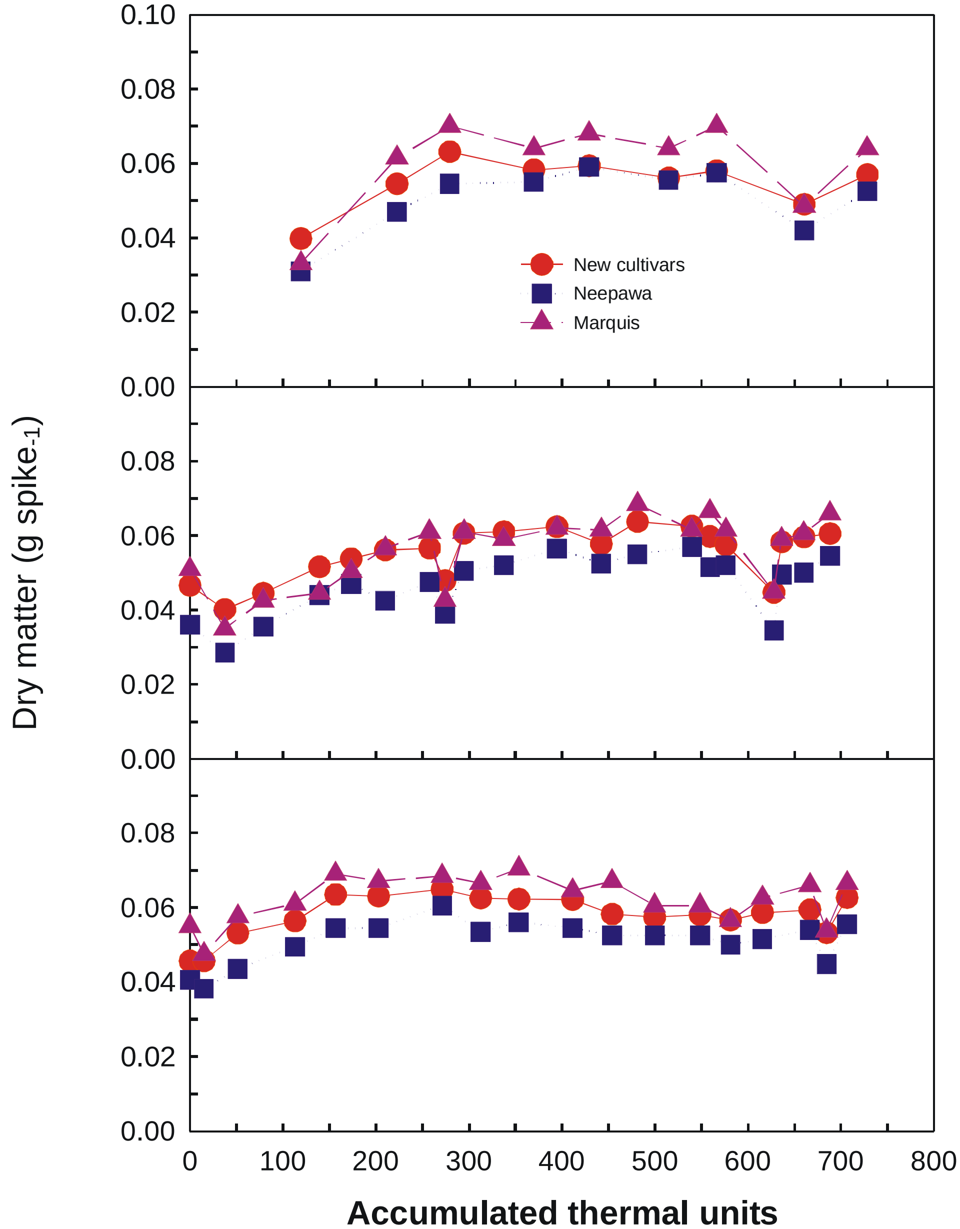

Fig. 3. Changes of rachis dry matter per spike.

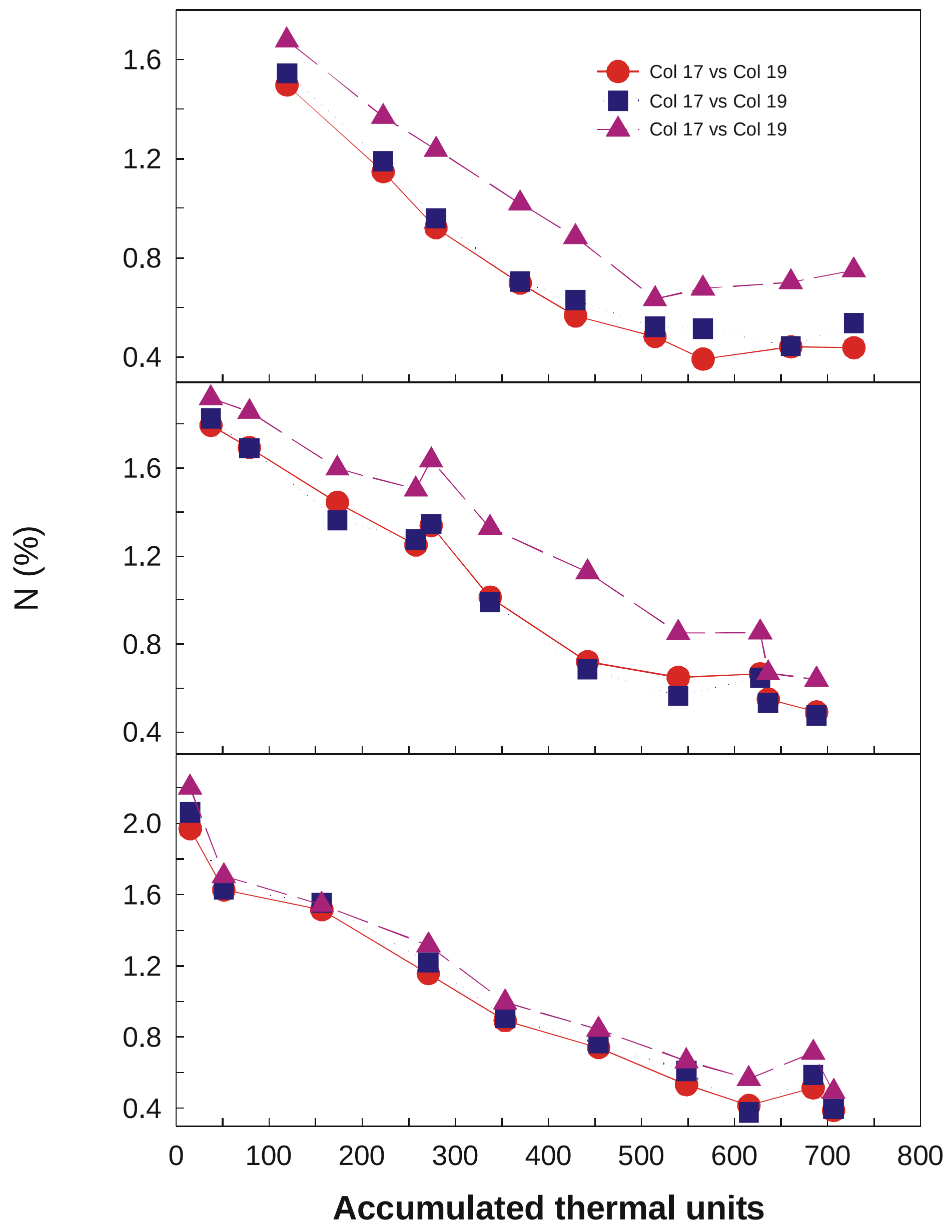

Fig. 4. Changes of glume N concentration.

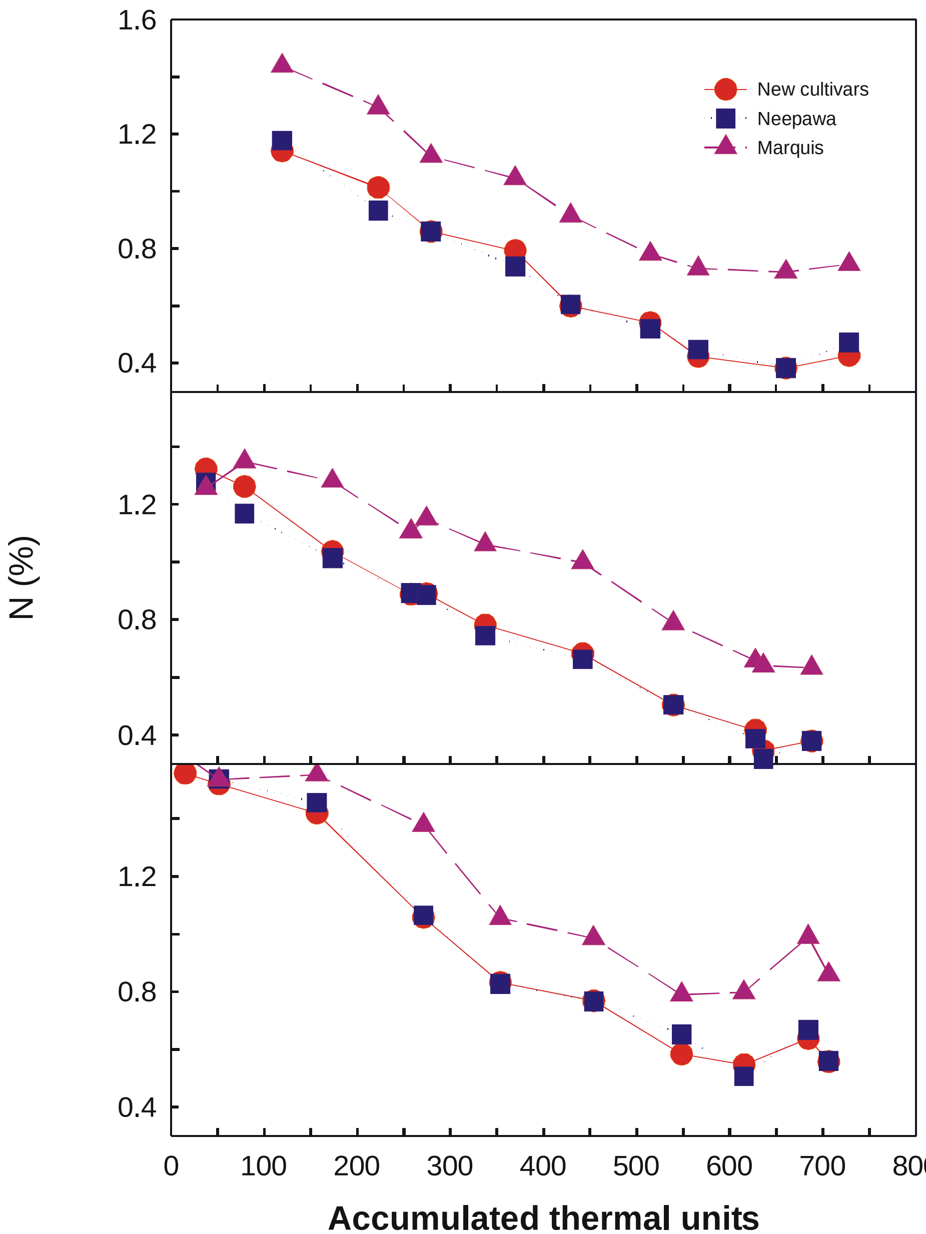

Fig. 5. Changes of rachis N concentration.