CHAPTER 4

THE HARVEST INDEX OF INDIVIDUAL EARS OF FOUR SOUTH AFRICAN WHEAT (*TRITICUM AESTIVUM* L.) CULTIVARS

4.1 ABSTRACT

Increasing the harvest index is a major route to higher yields in regions where a crop has had a lengthy period of selection and adaptation. No information could be found on differences in the harvest indices of the main stems and tillers of South African wheat cultivars. Consequently, this was determined for four wheat cultivars grown in a long-term fertilization and irrigation experiment at the University of Pretoria. A randomized complete block design in a split-plot arrangement, with three replicates, was used. The four cultivars did not differ in main stem (MS) harvest indices with a mean of 0.44. The harvest index of first tillers (T_1) differed significantly with SST 86 having the highest (0.48) and Carina the lowest (0.29), with that of Kariega and Inia intermediate between SST 86 and Carina. The low harvest indices of second tillers (T_2) indicate less effective utilization of resources by the tillers. The data indicates that individual wheat ears differ in the partitioning of assimilates to the grain and this may help in identifying genotypes more efficient in assimilate utilization for improved yield.

Key words: Biological yield, harvest index, main stem, tiller, *Triticum aestivum* L.

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4.2 INTRODUCTION

Migration Coefficient or Harvest Index is the proportion of dry matter of the entire ripe plant, excluding roots, that is accumulated in relation to the grain (Engledow & Wadham, 1923; Donald, 1962). In cereals, economic yield is the product of biological yield and harvest index

(Donald, 1962; Siddique & Sedgley, 1985). Donald & Hamblin (1976) argued that yield improvements could be achieved if a high harvest index was selected for in a competitive environment. Siddique, Kirby & Perry (1989) concluded from their study of ear:stem ratio's in old and modern wheat varieties grown in south-western Australia that improvement in grain yield resulted from reduced competition between stem and ear for dry matter, associated with a long-term trend towards a shorter life cycle and fewer stems. Fisher (1984), Amollo-Ocholla, Sedgley & Seaton (1986) and Amollo-Ocholla (1987) reported for cultivars widely grown in Western Australia an increasing yield trend with date of release. Increased yields were associated with increased harvest indices, reduced tillering capacity and earlier floret development. Other studies of historical cultivars generally show that increases in the potential grain yield were linked to increases in the harvest index (Blum, 1989; Austin, Bingham, Blackwell, Evans, Ford, Morgan & Taylor, 1980).

Fischer & Kertzer (1976) concluded that under optimal conditions of moisture and fertilizer application the harvest index offered promise as an early generation predictor of performance. On the other hand, Whan, Rathjen & Knight (1981) found that selection for improvement of grain yield using harvest index was no more effective than selection for yield directly, when considered across years. Rasmusson (1987) suggested that early generation selection for harvest index and for proven characters, followed in later generations by selection for yield stability across environments may, result in improved grain yield.

The main objective of this study was to extend the concept of harvest index to the individual shoots of a wheat plant using four South African wheat cultivars. Understanding harvest index differences among tillers can contribute towards improved breeding and selection, better crop modelling and improved yield prediction strategies.

4.3 MATERIALS AND METHODS

A long term-term fertilization and irrigation trial at the Hatfield Experimental Farm of the University of Pretoria was used. The experimental details, cultural practices, weather and statistical procedures are described in Chapter 2 and in Metho, Hammes, De Beer & Groeneveld (1997) and Metho, Hammes & Beyers (1998). In this study two soil fertility treatments (NPK and NPKM), representing well-balanced soil fertility situations, are considered (data not shown). Four cultivars Inia, Carina, Kariega and SST 86, treated as the split-plots were randomly sampled and separated into main stems (MS), first tillers (T_1), second tillers (T_2), and third tillers (T_3). Ears from the respective wheat shoots (MS, T_1, T_2 and T_3) were threshed separately, dried at 60 ^{0}C for 48 hrs, and weighed. Similarly, leaf and straw dry mass were determined. Harvest index was calculated as the ratio of grain yield to aboveground dry matter at maturity.

4.4 RESULTS AND DISCUSSION

The main effects of soil fertility and cultivar on harvest index of individual fertile wheat ears are presented in Table 4.1. Because of the erratic occurrence of higher order tillers (e.g. T_3, T_4) only main stems, first and second order tillers are discussed. Grain yield of main stems (MS), first tillers (T_1), second tillers (T_2), as well as relative mass of kernels and grain protein content in floret positions 1, 2, and 3 were discussed Chapter 3 and by Metho, Hammes & Beyers (1998).

Harvest index of individual wheat ears

The cultivars did not differ in mean harvest index and main stem harvest indices (Table 4.1). The harvest index of the cultivar SST 86 averaged 0.42 showing a high efficiency in carbon distribution to the ear. For the cultivars Inia, Kariega, and Carina the harvest indices were in the range of 0.34 to 0.36. This differs somewhat from the bulk harvest index values obtained on a plot basis as reported in Table 2.4.

Grain yield depends on effective translocation of current photosynthates to the grain, and is a more constant characteristic than biological yield for plants or varieties (Engledow & Wadham, 1923). Vogel, Allen & Patterson (1963) and Syme (1970) reported a significant correlation between grain yield and harvest index. The concept of harvest index when applied to the individual shoots of a plant may be useful in identifying characters that might increase yield (Takeda, Frey & Bailey, 1980). Islam & Sedgley (1981) for spring wheat, and Siddique & Sedgley (1985) for chickpea, reported that control of tillering or branching may maximize yield per ear.

Harvest indices of the first tillers differed significantly with SST 86 having the highest harvest index of 0.48 and Carina the lowest (0.29), while that of Kariega was intermediate (0.36). The second tillers did not differ significantly in harvest index, with indices between 0.22 and 0.33. On an individual shoot basis Inia exhibited the largest variation in shoot harvest index while SST 86 varied the least. For Carina first and second tillers did not differ (Table 4.1). The interaction between cultivar and soil fertility was not significant for harvest index.

TABLE 4.1 Effects of cultivar and soil fertility on mean harvest index, harvest index of main stem, first tiller and second tiller of four South African wheat cultivars

Treatment	Mean harvest index	HARVEST INDEX (H1)		
	$\frac{(\Sigma MS + T_1 + T_2)}{3}$	Main stem (MS)	First tiller (T_1)	Second tiller (T_2)
CULTIVAR				
SST 86	0.42	0.46	0.48	0.33
Inia	0.36	0.46	0.40	0.22
Kariega	0.35	0.41	0.36	0.27
Carina	0.34	0.43	0.29	0.29
LSD_T $P_{\leq 0.05}$	0.12	0.16	0.10	0.21
CV%	19.9	14.4	16.3	43.5

4.5 CONCLUSIONS

The data indicate that wheat cultivars differ in individual ear harvest indices and in the degree of partitioning of assimilates to the grain, and hence in effective utilization of resources. Understanding differences among tillers may help in identifying genotypes with improved yield potential in early stages of wheat breeding and selection.

4.6 REFERENCES

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