AN ANALYSIS OF YIELD COMPONENTS OF MAJOR TILLER ORDERS OF KOPARA WHEAT

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ABSTRACT

In a field experiment using tagged plants, the components of yield of major tiller orders were analysed for a standard height wheat cv. "Kopara".

Despite tiller mortalities of 62%, yields of over 6 t ha^{-1} were obtained. Yields were higher at twice the recommended sowing rate, and increased when irrigation was applied after ear emergence and with N at 90 kg ha^{-1}. Yield differences were ascribed to the composition of the ear population. The first-formed main stem tiller had the highest values of yield components, and contributed most to yield.

INTRODUCTION

In wheat grown in Canterbury, variation in the density of ears accounts for most of the differences between grain yields (Dougherty 1973; Scott *et al.* 1977; Scott 1978). Spike populations are largely determined by tillering activity during August and September (Fraser 1978). However, not all of these tillers survive to produce a mature ear, and tiller mortalities of 40% and over are common (Dougherty and Langer 1974; Fraser and Dougherty 1977).

In a previous field experiment, it was shown that the standard height Kopara wheat tended to have a heavier grain weight per ear in its surviving tillers despite a higher tiller mortality than a semidwarf wheat (Fraser and Dougherty 1977). This paper examines the yield components of those tillers in Kopara which survived to produce an ear. As in previous work, N fertilizer, irrigation and sowing rates were used to alter the structure of the tiller populations.

MATERIALS AND METHODS

Eight combinations of treatments out of a larger factorial of 24 treatments with two replicates were used in the experiment which was sown on June 16 1977 at the Lincoln College Research Farm. Each plot was 50 m long x 1.5 m wide with 10 rows at 15 cm row spacing. Previously the Templeton silt loam site was occupied by lucerne which had been rotary hoed, ploughed and top worked. The treatments and their levels were as follows:

Sowing rates:	SO:	250 viable seeds m^{-2}
	Sl:	500 viable seeds m^{-2}
Irrigation:	O:	none
	I:	irrigation at intervals to field capacity from 28 November to 12 December after ear emergence
Nitrogen fertilization:	NO:	none
	N90:	N at 90 kg ha^{-1} applied on 23 August 1977

Two 0.1 m^2 quadrats were randomly placed in each plot. In each quadrat, 10 plants were observed at weekly intervals, and the time of appearance and senescence of different tiller orders recorded. The order of tiller appearance was: main stem, then tillers in the axils of leaf 1, leaf 2 and leaf 3 on the main stem (called T1, T2 and T3 respectively). When mature, plants in 0.1 m^2 quadrats in each plot were dug up and the roots cut off. Labelled plants were fractionated into MS, T1, T2 and T3 groups. Spikelets were counted on each group of ears, which were then oven-dried at 80°C, weighed and the grain extracted.

RESULTS

Results are presented for the main stem and first two tillers as only 7 out of 320 plants labelled had a tiller 3 which survived until harvest.

Effects of sowing rate

Yield was increased by 11% at the higher sowing rate. This was partly related to a high population of main stems which contributed 90% to yield. Number of ears per plant were lower at densities of 500 plants m^2 and this would partly account for the significantly lower grain yield per plant (Tables 1 and 2).

TABLE 1: Main effects of sowing rate, irrigation and nitrogen fertilizer on plant establishment, ear population and yield

Treatment		Establishment (plants m^{-2})	Ears m^{-2}	Yield (g m^{-2})	Yield plant^{-1} (g)
Sowing rate	SO	250	464	711.8	2.84
	Sl	520***	599***	790.5 *	1.58***
Irrigation	O	400	525	714.4	2.15
	I	390	538	788.0*	2.26
Nitrogen	N0	390	466	676.9	1.94
	N90	390	598***	825.5**	2.48**
S.e. of mean		6.7	14.5	23.0	0.08
Significant interactions		none	SxN*	none	none

TABLE 2: Effects of sowing rate, irrigation and N fertilizer on tiller survival. The number of plants (out of 20) which produced an ear are shown in brackets

		NUMBER OF EARS PLANT^{-1}			
Treatment		MS	T1	T2	Total
Sowing rate	SO	1.00 (20)	0.413 (8)	0.400 (8)	1.856 (20)
	S1	1.00 (20)	0.100 (2)***	0.056 (1)***	1.156 (20)***
Irrigation	O	1.00 (20)	0.275 (6)	0.225 (5)	1.531 (20)
	I	1.00 (20)	0.238 (5)	0.231 (5)	1.481 (20)
Nitrogen	NO	1.00 (20)	0.138 (3)	0.100 (2)	1.244 (20)
	N90	1.00 (20)	0.375 (8)***	0.356 (7)***	1.769 (20)***
S.U. of mean			0.020	0.035	0.061
Significant interactions		none	SxN**	SxN**	SxN**

The components of spike yield especially in T1 and T2 ears were greatly reduced by seeding rate (Table 3), but these reductions were evidently not enough to depress yield per unit area.

Effects of irrigation

Irrigation resulted in higher yields per spike when applied to wheat grown at the higher sowing rate. It increased grain number per spikelet and, hence, grain weight per ear in the MS and T1 ears, but depressed yield of T2 spikes. Irrigation was applied too late to affect tiller production or mortality.

Effects of nitrogen fertilizer

The 22% increase in grain yield attributable to N applied at the early tillering stage was partly due to higher numbers of mature ears per plant and higher yields per plant (Tables 1 and 2) with the MS, T1 and T2 tillers contributing 66.9%, 17.1% and 16% to yield respectively. Nitrogen fertilizer resulted in more ear numbers per plant at the low density (Table 4).

Values of yield components of all tiller groups were higher when N was applied, especially spikelet number per ear. This, together with an increase in grain number per spikelet in all groups accounted for the increase in yield per plant with this treatment (Table 1).

DISCUSSION

Yields in excess of 6 t ha^{-1} (14% moisture content) were obtained despite high tiller mortalities of up to 62% (Fraser 1978). High mortalities were also recorded in the previous season's work and it was suggested that it may have been due to intense interplant competition for light during stem extension when tiller mortality is severe (Dougherty *et al.* 1974a; Fraser and Dougherty 1977; Fraser 1978) and internal competition within plants at the same time when the stem sink is strong (Patrick 1972). This would lead to self-thinning of tillers (Kays and Harper 1974) and, with stem extension, a lower extinction coefficient (Evans and Wardlaw 1976) and the subsequent improvement in assimilate levels. Self-thinning, primarily of these later formed tillers resulted in an ear population of 532 ears m^{-2} – similar to that of the 1975 season where yields in excess of 6 t ha^{-1} were obtained with a Leaf Area Index of 3 during stem extension (Scott 1978).

The surviving tillers showed a strong hierarchical relationship. The first-formed main stem had the highest values of all the spike yield components irrespective of treatment. T2 showed the most response to agronomic treatments, and the main stem was least affected. The subordinate status of the T1 and T2 tillers may be related to the initial size of their respective apical meristems, for Fletcher and Dale (1977) showed that the main stem had a much larger apex than the tillers. As T1 and T2 emerged later than the main stem (Fraser 1978) but became reproductive about the same time, they would have a shorter period of stacking of floral primordia and hence have fewer spikelets per ear.

Yields this year were not depressed by high sowing rates as they have been in some years (Scott *et al.* 1975) but some individual yield components of ears were reduced (Table 3). This may have been due to interplant competition in what was a population dominantly of main stems, which are known to have higher leaf areas than tillers (Fraser 1978; Power and Alessi 1978). This inter-plant competition for light and nutrients by the main stems may have restricted the amount of carbohydrate available to the growing ear (Dougherty and Langer 1974; Dougherty *et al.* 1975) and thus have reduced the number of grains per ear (Willey and Holliday 1971) (Table 3).

Nitrogen fertilizer significantly increased yield per ear, and hence yield per plant and per unit area. The origin of this response appears to be due to the fertilizer's effect on increasing ear numbers per plant (Table 2) as well as spikelet number per ear and grain number per spikelet (Table 3) in all tiller groups. Increases in spikelet number per ear with N are consistent with previous experiments at Lincoln College (Dougherty *et al.* 1974b; Scott *et al.* 1975). The increase in grain set observed with N may be attributable to high levels of plant available soil N during pre-anthesis floret development (Scott 1978). According to Dougherty *et al.* (1978), N fertilizer may increase grain set if carbohydrate is not limiting, or depress grain set if it intensifies a deficiency of carbohydrate.

The overall yield increase attributable to irrigation supports other local work (Drewitt 1973; Wilson

TABLE 3: Effects of sowing rate, irrigation and nitrogen fertilizer on yield components of ears of Kopara wheat

(Significance levels: *$p \leqslant 0.05$ ** $p \leqslant 0.01$ *** $p \leqslant 0.001$) (S.e. of mean = standard error of mean of each column).

		SPIKELET NUMBER EAR^{-1}				GRAIN NUMBER SPIKELET^{-1}				GRAIN NUMBER EAR^{-1}				WEIGHT/GRAIN^{-1} (MG)				GRAIN WEIGHT EAR^{-1} (g)			
		MS	T1	T2	Mean	MS	T1	T2	Mean	MS	T1	T2	Mean	MS	T1	T2	Mean	MS	T1	T2	Mean
Sowing rate	S0	18.19	17.11	17.10 *	17.65	2.55	1.95	1.93 **	2.29	46.4	33.4	33.1 **	40.4	39.2	38.4	38.8 **	38.9	1.820 ***	1.284	1.291 **	1.574 ***
	S1	17.68	12.25	10.63	17.50	2.36	1.36	1.12	2.24	41.2	22.1	19.1	39.4	35.8	27.7	22.5	35.9	1.423	0.823	0.683	1.365
Irrigation	0	18.03	14.53	14.88	17.57	2.26	1.58	1.69	2.10	40.8	26.2	28.8	37.0	38.2	32.5	32.9	38.0	1.565 **	0.983	1.088	1.407 **
	I	17.84	14.82	12.85	17.58	2.65	1.73	1.36	2.43	47.5	29.2	23.3	42.8	36.8	33.6	28.4	36.9	1.678	1.125	0.886	1.531
Nitrogen	N0	17.46	12.40	10.91 *	17.33	2.34	1.64	1.26	2.26	40.9	27.0	22.1	39.2	39.1	29.3	25.0 *	39.1	1.606	1.056	0.885	1.536 **
	N90	18.41	16.96	16.82	17.82	2.57	1.67	1.79	2.28	47.4	28.4	30.1	40.6	35.9	36.8	36.3	35.7	1.637	1.051	1.090	1.402
S.E. of mean		0.31	1.85	1.58	0.26	0.18	0.30	0.17	0.13	3.4	4.8	3.2	2.5	1.6	4.5	3.4	1.5	0.019	0.185	0.123	0.021
Significant interactions		none	none	SxN**	none	none	none	SxN**	none	none	none	SxN**	none	none	none	SxN**	none	SxI*** SxN***	none	SxN**	SxI** SxN***
Grand mean		17.93	14.68	13.86	17.58	2.45	1.65	1.53	2.26	44.1	27.7	26.1	39.9	37.5	33.0	30.6	37.4	1.62	1.05	0.99	1.47

TABLE 4: Interaction of sowing rate and nitrogen fertilizer on number of ears per plant

Plants m^{-2}	NO	N90
250	1.450	2.263
500	1.038	1.275

L.S.D. $P \leqslant 0.05 = 0.291$

1974), although, in some cases, irrigation can depress yield by encouraging vegetative growth at the expense of reproductive development (Dougherty and Langer 1974). In this experiment, on a moisture-retentive silt-loam soil, moisture levels were likely to be non-limiting until after ear emergence. By this time, tiller mortality had ceased (Fraser 1978) and the effect of irrigation was to mainly delay senescence of the flag leaf (W. Dalgliesh *pers. comm.*).

Most of the variation in yield was accounted for by changes in ear numbers which were positively correlated with yield (r = +0.88***). This would suggest that increases in yield could be attained by using treatments that favour tiller survival of T1 and T2 tillers. Earlier applications of N may be one easily employed method.

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