EFFECTS OF SOWING RATE AND NITROGEN FERTILIZER ON TILLERING OF "KARAMU" AND "KOPARA" WHEATS

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ABSTRACT

A semidwarf wheat cultivar "Karamu" and a standard wheat cv. "Kopara" were sown at 250 and 500 seeds/m^2 on a low fertility Templeton silt-loam in May. Nitrogen fertilizer (90 kg/ha) was applied in August and the production and senescence of tillers on permanently tagged plants were recorded at weekly intervals. Increments in sowing rate and nitrogen fertilizer increased the tiller population but did not change the tillering pattern. Differences in tillering patterns of cultivars were related to differences in the rate of development. Grain yield/ear was higher in the standard wheat but the semidwarf compensated with a higher tiller survival to maturity. All treatments affected tiller survival, but virtually all mainstems matured irrespective of treatment. Survival of tillers was low in later-formed tillers and they contributed little to grain yield. The main stem contributed up to 88% to the final yield. Results are discussed in relation to crop development and differences in tiller mortality.

INTRODUCTION

Tillering in wheat is known to be highly dependent on nitrogen (Dougherty *et al.*, 1974) and plant density (Dubey & Lal 1970; Malik 1969). Semidwarf wheats may produce more spikes/plant compared to standard wheats (Vogel *et al.*, 1963; Porter *et al.*, 1964) but others have reported no differences in ear number between the two types of wheat (e.g. McNeal *et al.*, 1960), and Johnson *et al.*, (1966) showed that semidwarf varieties may be inferior. These differences in ear and tiller number are attributable to variation in the cultivars capacities to maintain and/or produce tillers and, presumably, genotype-environment interactions.

The rate of tiller production increases rapidly in early spring and ceases about the onset of stem elongation, (Watson *et al.*, 1958; Thorne 1962). About 50% of tillers live to produce a mature spike (Scott *et al.*, 1973; Dougherty & Langer 1974; Langer 1965). From previous field experiments at Lincoln College (Scott *et al.*, 1973; Dougherty *et al.*, 1974), it has been suggested that the tillers which die reduce grain set in the remaining spikes because they compete with the preanthesis ear for light, water and other factors.

The experiment described in this paper was designed to study the tillering pattern of different orders of tillers in the semidwarf Karamu and standard Kopara wheats. Nitrogen fertilizer and sowing rates were varied to alter the structure of the tiller populations. In this experiment, we attempted to evaluate the production, senescence, and survival of tillers and the contribution of ear-bearing tillers to grain yield.

METHODS

This experiment was carried out at the Lincoln College Research Farm on a nitrogen-deficient Templeton silt-loam soil. On 28th May 1976 a 2 x 2 x 2 factorial with two replicates was drilled with a basal dressing of 250 kg/ha superphosphate in two randomised blocks. Each plot was 50m long with 10 rows at 15 cm spacing. The three factors and their levels were as follows:

Sowing rates:	SO:	250 viable seeds/m^2 (recommended)	
	S1:	500 viable seeds/m^2	
Cultivars:	CO:	Karamu (semidwarf)	
	C1:	Kopara (standard)	
Nitrogen fertilization:	NO:	None)	applied at the tillering/double ridge stage on 8th September 1976
	N1:	90 kg/ha)	

Establishment counts were taken, and one 0.1 m^2 quadrats on each plot were thinned to 25 and 50 plants/0.1 m^2 for the low and high sowing rates respectively. 10 seedlings without coleoptile tillers were selected from each quadrat and permanently marked. Using coloured wire loops, the time of appearance and senescence of each type of tiller was monitored on these plants at weekly intervals.

Tiller nomenclature (after Rawson 1971) was used, i.e. primary tillers arising from the axils of the first, second and third leaves of the main stem were called T1, T2 and T3. Tillers were labelled as they appeared, starting at 12 weeks after sowing date.

At maturity, the monitored plants were harvested separately and the components of yield for the main stem and each tiller group were determined.

In addition, fortnightly samples of plants were taken to check on the stages of development in relation to cultivar and sowing density.

Quadrats were harvested in early February, and an assessment made of the percentage contribution of each tiller to yield based on grain weight per ear.

RESULTS

Tillering occurred in a regular sequence being in the order of T1, T2 and T3. A maximum of 5 tillers per plant (including the main stem) was recorded whereas normally up to 8 tillers/plant may be produced (W. Scott, *pers. comm.*). Tillering may have been limited by lower than average levels of solar radiation during the tillering period.

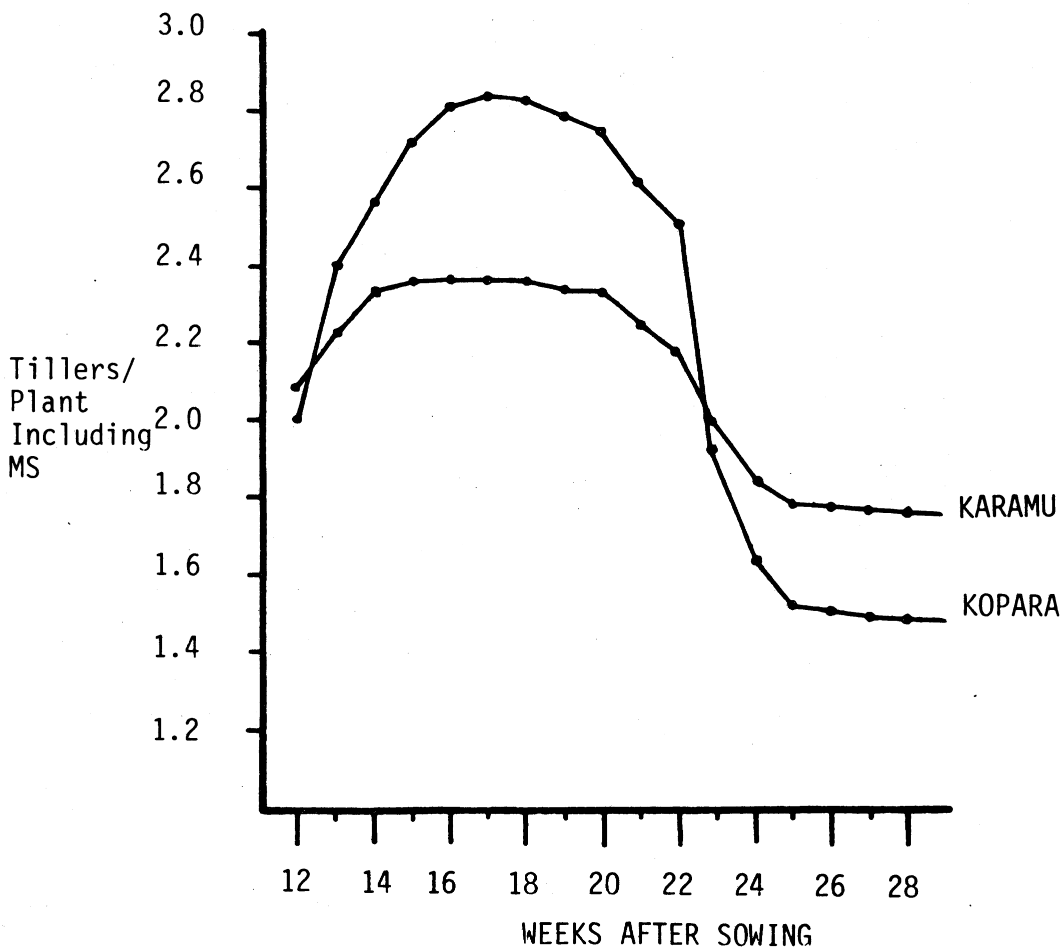

FIG. 1. Variety differences in tiller number per plant averaged over sowing rates and nitrogen treatments.

TABLE 1: Effects of sowing rate, variety and nitrogen on plant establishment, yield, and percentage tiller contribution to yield

Treatments	Establishment (plants/0.1 m^2)	Ears/ 0.1 m^2	Yield g/0.1 m^2	MS	% contribution to yield T1	T2	T3	Total
SO	25	57	59.7	64	25	10	1	100
S1	50	70***	59.6	88	9	3	0	100
CO	37	73	59.9	68	22	9	1	100
C1	37	54***	59.5	77	17	6	0	100
NO	37	61	55.7	76	17	7	0	100
N1	37	67	63.6	70	21	8	1	100
Interactions		SxCxN*	SxCxN*					

Reproductive events of Kopara commenced about two weeks later than Karamu. This difference was reflected in the overall as well as the individual patterns of tillering; Karamu having its maximum rate of tillering about the 13th September (15 weeks after sowing) and Kopara about the 27th September (17 weeks after sowing). (Figure 1).

The sowing rate treatment had a very pronounced effect on tillering, affecting the peak and final number of tillers (Figure 2), but it did not influence the tillering patterns.

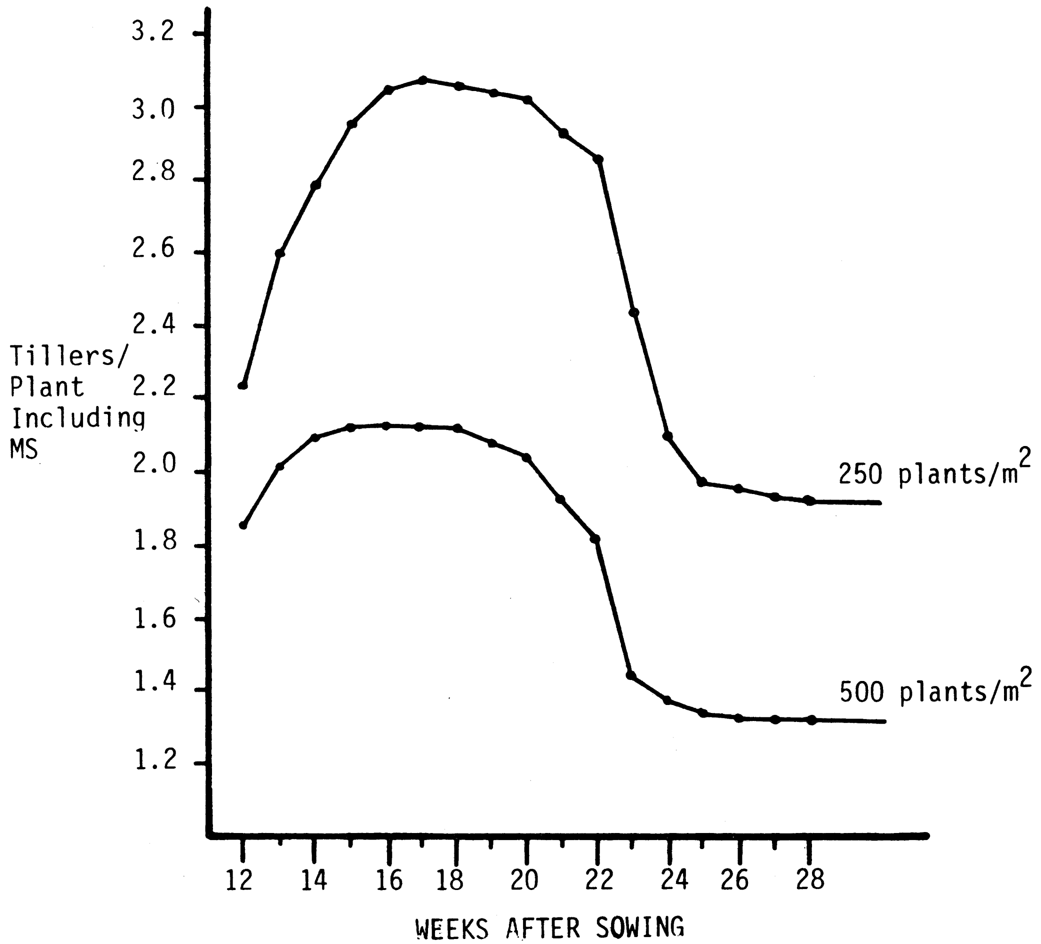

FIG. 2. Effects of sowing rate on tiller number per plant averaged over varieties and nitrogen treatments.

The greater production and survival of tillers at the lower sowing rate more than compensated for the low plant populations (Table 1). However, the ear number (MS and all tiller groups) was still higher at 50 plants/0.1 m^2 despite a lower percentage survival of ear-bearing tillers.

Differences between the overall tillering pattern of Karamu and Kopara were highly significant ($p=0.001$), and were partly due to the differential production and senescence of the T1, T2 and T3 tillers (Figure 3), and partly due to the different rates of ear development in relation to stem elongation (Figure 4).

At both sowing rates Kopara produced slightly more tillers at its maximum (820 and 730 tillers/m^2) compared to Karamu which produced 800 and 700 tillers/m^2 at the high and low sowing rates respectively. Tiller death rates of Kopara reached a maximum of 145 at low plant densities and 290/m^2/week at high densities during stem elongation between November 1st and November 8th. Karamu had a much lower tiller death rate at the same time with 55 and 110 tillers/m^2/week at low and high plant densities respectively. Therefore, by the time of ear emergence the percentage survival of tillers was considerably lower in the standard wheat than in the semidwarf (Table 2).

TABLE 2: Effect of sowing rate, cultivar, and nitrogen fertilization on percentage survival of tillers which reached ear emergence

Treatment	MS	T1	T2	Total Tillers
SO	100	28	15	45
S1	100	24	6	32
CO	100	39	14	54
C1	100	13	8	23
N0	100	23	9	33
N1	100	29	12	44
Interactions		SxC* SxCxN**	SxN*	SxN*

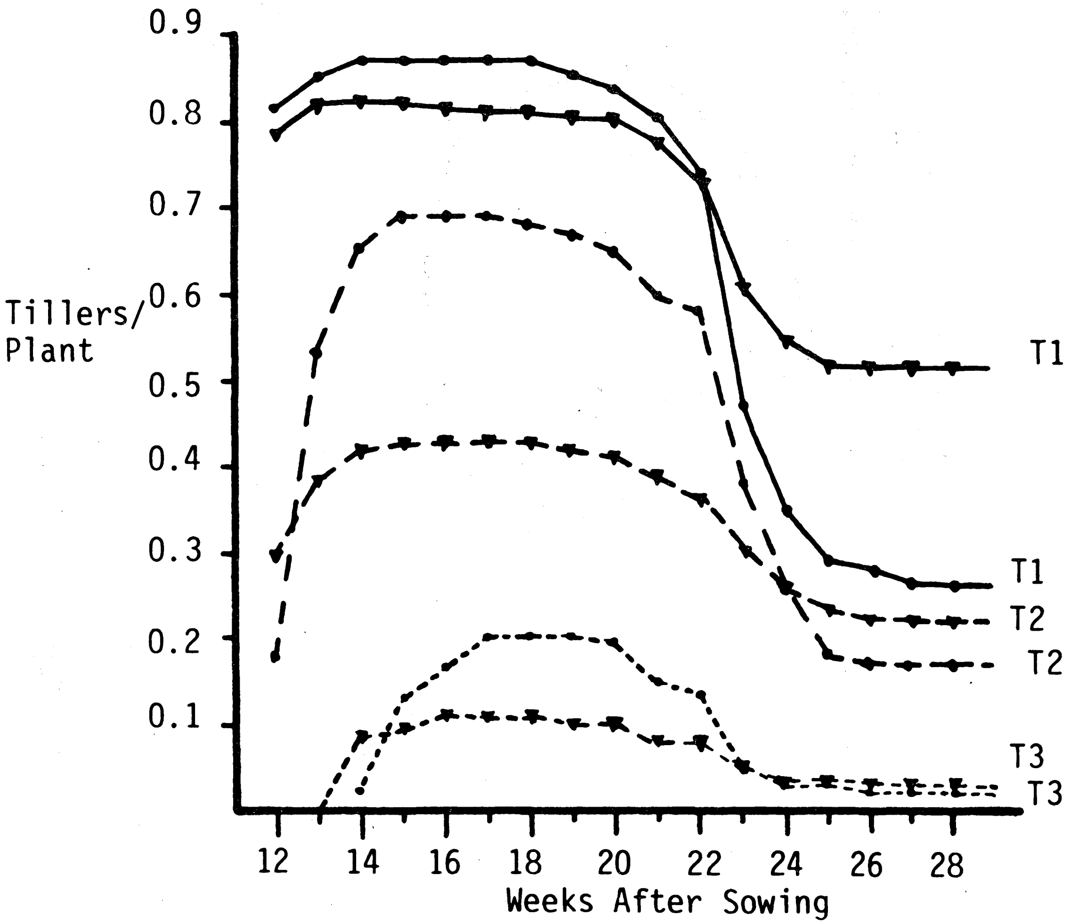

FIG. 3. Tillering patterns of Karamu ▼—▼ and Kopara ●—● averaged over sowing rate and nitrogen treatments.

Nitrogen applied at the double-ridge stage promoted tiller survival (Figure 5). A significant (p=0.05) S x N interaction showed that nitrogen was effective only at the low sowing rate where 57% of the total t'''ers and 22% of the T2 tillers survived to maturity.

Grain yields were not significantly affected by the treatments imp)sed, but the analysis of variance revealed that grain weight/tiller and grain weight/main stem and T1 ears were higher in Kopara than Karamu despite heavy tiller mortality in this variety (Table 3). Grain weight/tiller and grain weight per MS, T1, and T2 tillers were much lower at the higher sowing rate (p=0.001). However, yield per ear was offset by the number of ears/quadrat which compensated for the reduced grain weight at 50 plants/0.1 m^2 (Table 3).

TABLE 3: Effects of sowing rate, cultivar, and nitrogen fertilizer on mean grain yield/tiller (g)

Treatment	MS	T1	T2	T3	Total Tillers
SO	1.20	0.86	0.69	0.16	1.06
S1	0.90***	0.44**	0.32*	0	0.87**
CO	0.95	0.65	0.50	0.11	0.83
C1	1.16	0.65	0.51	0.05	1.11
NO	0.97	0.97	0.45	0.07	0.95
N1	1.13**	1.13**	0.55	0.09	0.99
Interactions	SxN*				SxN*

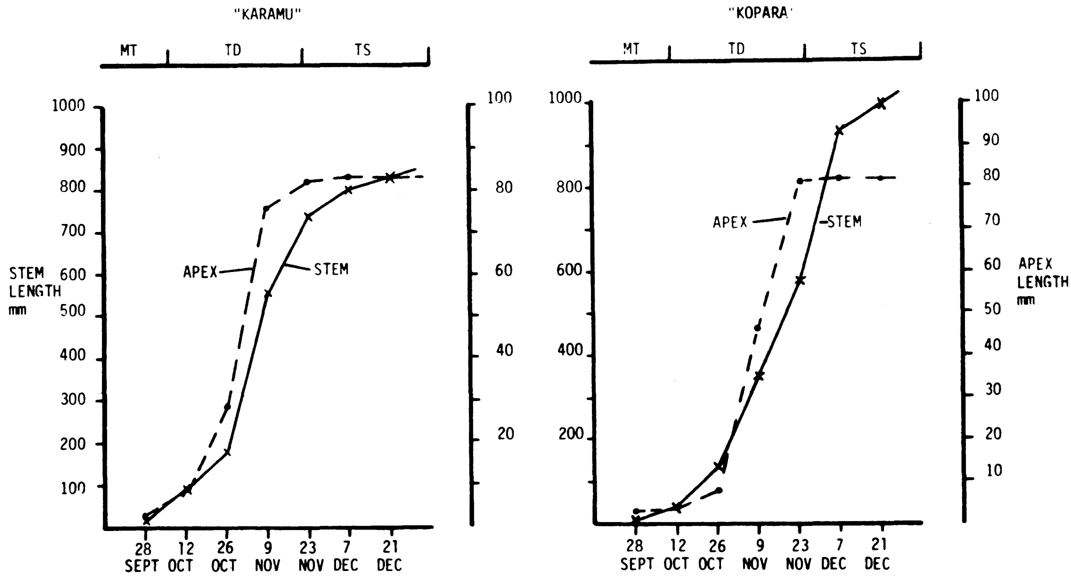

FIG. 4. Development of the apex (ear) and stem to tillering in Karamu and Kopara. MT = maximum tillering TD = tiller death TS = tiller survival.

The main stem ears contributed proportionately far more to the total grain yield than any other ears (Table 1). At the commercial sowing rate of 250 plants/m^2, 99% of the total grain weight was produced by the main stem (64%) and T1 and T2 (35%). At the higher sowing rate, surviving T1 and T2 tillers contributed only 12% of yield. Kopara's main stem contributed more to yield compared to Karamu and its fewer later formed tillers contributed only 23%. Nitrogen at 90 kg/ha caused the T1 to contribute relatively more to grain yield.

DISCUSSION

The overall production and death of wheat tillers was similar to the pattern of tillering recorded by Clements *et al.*, (1974) and Rawson (1971). Figure 4 shows that the period of maximum tillering ceased about internode elongation, and that tiller death mainly occurred during the period of rapid stem and apex development. These results agree with other authors (Langer *et al.*, 1973; Dougherty *et al.*, 1974). Data on tillering of Karamu agrees with those of Dougherty *et al.* (1975) who showed that Karamu produced fewer tillers per plant and, consequently had lower rates of tiller mortality.

It should be noted that for purposes of experimentation, Karamu was sown during winter, not in spring as recommended. The yields of Karamu when sown in winter are generally not superior to standard New Zealand cultivars such as Aotea and Kopara, and this contrasts with normal spring sowings. On 11 November 1976 when Karamu was at ear emergence and Kopara was at the boot stage, a frost occurred (-2°C. air temperature) which may have reduced grain set in Karamu.

Water stress, a common cause of tiller mortality in Canterbury, may be largely eliminated in this particular season, for soil water levels were not limiting during the period of tiller death. In another nearby experiment however, soil moisture levels under Karamu were generally higher than under Kopara indicating that the semidwarf crops consumed less soil water, and should be consequently, subjected to less water stress in normal drier years.

The more stable tiller population in the semidwarf Karamu may be related to its earlier reproductive development. Thus Kopara, which had a longer time span between establishment and the double ridge stage, produces more tillers and, consequently, has greater tiller mortality.

The higher tiller populations of Kopara may have resulted in more self-thinning (Kays & Harper 1974) for leaf area indices are closely related to tiller populations during the period of tiller production and tiller senescence (Scott & Dougherty 1977). Karamu exhibits other characteristics of semidwarf wheats such as a more upright leaf configuration, which should reduce its canopy extinction coefficient (Evans & Wardlaw 1976). However, this advantage over Kopara, may be countered by the effects of its short internodes on reducing canopy height, thereby increasing its extinction coefficient. The later formed and lower order tillers, are those which are likely to succumb to the stresses which cause self-thinning. Intra-tiller and inter-tiller competition for assimilates within the Karamu population may be less intensive than experienced by the standard wheat for the semidwarf should require less energy for the growth and maintenance of stem internodes. One factor favouring the later flowering Kopara, however, are the slightly more favourable radiation and

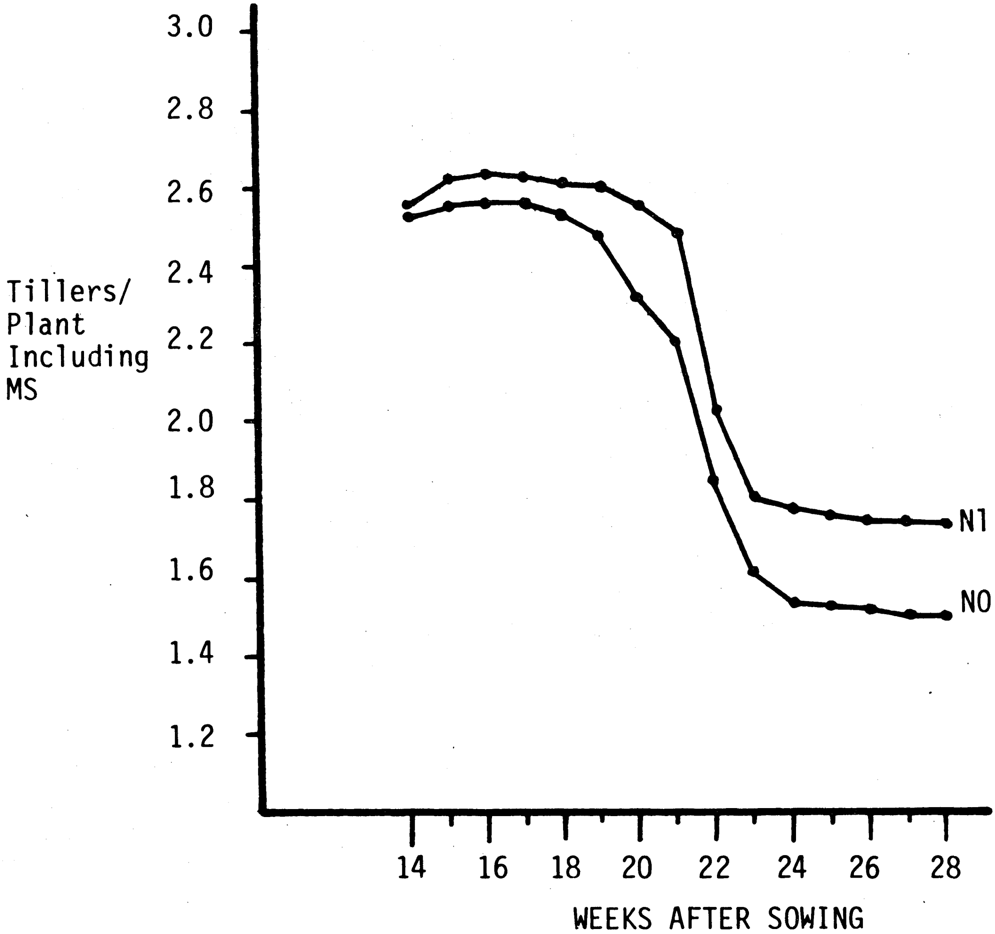

FIG. 5. Effects of nitrogen application on tillering averaged over sowing rates and varieties.

temperature regimes during the period of tiller mortality.

Although the tillering pattern was similar at the two sowing rates, the rate of tiller production was significantly lower at the high sowing rate right from the onset of tillering. Since none of the main stems on the 320 pl. nts monitored died, this would suggest that inter-plant as well as inter-tiller competition starts at a much earlier stage than indicated by Puckridge (1962). Early increases in tiller and, therefore, leaf numbers in a high (and predominantly main stem) population may have reduced light intensity and consequently tiller production (Friend 1965).

In this experiment, nitrogen increased tiller production and survival as well as grain yield/ear but earlier work by Dougherty *et al.*, (1974) showed that nitrogen could depress yield by decreasing tiller survival. However, it should be noted that in the 1971-72 season, ear populations were considerably higher than in this experiment.

Whilst it would seem desirable to maximise the grain yield of the main stem ear on account of its high survival and contribution to yield, compensation by limited tillering maybe a highly desirable characteristic since seed bed conditions may result in variations in attained plant density (Austin *et al.*, 1975). Results from this experiment have shown that at high plant densities grain weight/ear is reduced.

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