J. Agronomy & Crop Science 168, 100—107 (1992)

ISSN 0931-2250

Departamento de Biología Vegetal, Universidad de Granada

Leaf Area, Grain Yield and Yield Components Following Forage Removal in Triticale

L. F. GARCÍA DEL MORAL

Author's address: Prof. Dr. L. F. GARCÍA DEL MORAL, Dpto. Biología Vegetal, Facultad Ciencias, 18001-Granada, Spain.

With 2 figures and 5 tables

Received June 4, 1991; accepted September 10, 1991

Abstract

Triticale (×*Triticosecale* Wittmack) is a cereal that can be simultaneously used for forage and for grain, but this dual purpose is currently limited by a lack of information concerning the effects of forage removal on grain production. Thus, the effect of one or two successive cuttings (simulated grazing) on grain yield, yield components in the main stem and tillers, leaf area and biomass development were studied in four hexaploid triticales grown under irrigation and with high soil fertility. Forage removal reduced grain yield and grain weight per plant in proportion to the number of cuttings, mainly by reducing the number of tillers with spikes at harvest. Whereas foliage reduction did not affect the number of spikelets per spike, kernels per spike, or floral fertility in the main-stem spike, these yield components were drastically reduced in the spikes of tillers. Forage removal affected mean weight per kernel to approximately the same extent in the main stem as in the tillers. The Leaf Area Index (LAI) at anthesis showed significant loss due to cutting, mainly because of a decrease in the number of leaves per plant and in the green area per leaf. This caused similar decreases in the Leaf Area Duration (LAD) from anthesis to maturity. A strong inverse relationship was found between the percent of loss in LAI at anthesis and the final grain yield, suggesting that grain yield was largely dependent upon the ability of the crops to produce new leaf tissue rapidly in the time between cutting and anthesis.

Key words: Triticale, forage, leaf area, grain yield.

Introduction

Triticale (×*Triticosecale* Wittmack), a relatively new cereal, can be used simultaneously for forage and grain production. Generally, triticale is grazed one or two times during the early stages of growth (prior to jointing) and later is allowed to produce a grain crop. Its management as a dual-purpose crop, however, is currently limited by a lack of knowledge concerning the impact of forage removal on the plant growth and grain yield.

Forage removal usually modifies plant tillering, stem elongation and subsequent growth of leaves and roots (MILTHORPE and DAVIDSON 1966). It also influences grain yield, depending on environmental conditions, moisture and fertility of the soil, management practices and plant genotype (DUNPHY et al. 1982, POYSA 1985). Increases in grain yield following grazing have been associated with reduced lodging (DAY et al. 1968), whereas decreases in grain yield are mainly attributed to a reduced number of spikes per m^2 at harvest (DUNPHY et al. 1982, BRIGNALL et al. 1988).

The timing and number of the cuttings can affect forage production and grain yield in both wheat (DUNPHY et al. 1982) and triticale (POYSA 1985, BRIGNALL et al. 1988). Forage harvesting should be completed by the early-joint stage in order to produce maximum grain

U.S. Copyright Clearance Center Code Statement: 0931-2250/92/6802-0100$02.50/0

yield (DUNPHY et al. 1982, POYSA 1985). Late forage harvest diminishes grain yield due to less tiller survival and fewer kernels per spike, but has little effect on the average weight per kernel (DUNPHY et al. 1982). Forage harvest at the late-joint stage can remove apical meristem, thus requiring the regrowth from the slower and less productive dormant tiller buds (HYDER 1972).

This study investigates the effects of one or two cuttings (simulated grazing) on grain yield, yield components and leaf area in hexaploid triticale grown under irrigation and with high soil fertility in southern Spain.

Materials and Methods

During the 1986 season, four cultivars of hexaploid triticale (*Cananea, Trujillo, Tejon/Bgl* and *Tritibat*) were tested for forage production and grain yield in southern Spain. Each cultivar was sown at an adjusted density of 150 kg/ha in six-row 10 m-long plots with 0.20 m interrow spacing and separated by 1/2 m-wide uncultivated pathways. The crops were seeded on 20 Dec. 1985 on a calcaric fluvisol soil (according to FAO classification) and were harvested in mid-July 1986. The plots were irrigated four times from tillering to early ripening.

The experimental design was a split plot, replicated three times, with cultivars as the main plots and cutting treatments as the subplots. All plots were fertilized uniformly with 72 kg N/ha, 135 kg P_2O_5/ha and 135 kg K_2O/ha prior to planting, and top-dressed with 92 kg N/ha at tillering and with 33.5 kg N/ha at jointing. Three treatments were compared: C_0, an uncut control; C_1, one cutting made at the end of tillering in Zadoks' stage 30 (pseudo stem erection); and C_2, one cutting made at C_1, followed by a second cutting in Zadoks' stage 31 (first node detectable). Each cutting reduced the entire plot to a height of 2—3 cm without removing any of the growing points, after which the forage was gathered and weighed.

In each plot, the number of plants in one 50 cm-long row was recorded (throughout the principal stages of development, starting prior to the first cut) at intervals of about 15 days, according to Zadoks' scale as illustrated by TOTTMAN and MAKEPEACE (1979). Later, in the laboratory, five representative plants per plot were selected to establish the following primary values per plant: (a) total dry matter excluding roots, and separate dry-weight values of leaves, tillers and spikes (after drying at 60—70 °C to constant weight); (b) leaf-lamina area (using a photoelectronic planimeter LI-COR 3000); (c) number of leaves, number of tillers and number of tillers with spikes. The values of growth indexes were calculated according to RAMOS, GARCÍA DEL MORAL and RECALDE (1982 and 1985).

For measuring the yield components, plants were taken from a one-meter-long row in each plot before harvest. After counting the number of plants and spikes in this sample, ten representative plants were selected which provided the number of spikes per plant. In addition the following measurements were made for the main stem and for tillers: number of spikelets per spike; number of seeds per spike; total seed weight; and spike length (measured from the collar to the apex of the last spikelet). From these data the number of spikes per m^2 and the seed weight per plant were obtained and a weighted average per plant was calculated for the spikelet per spike, the number of seeds per spikelet, the number of seeds per spike and the mean weight per seed. The weight of the total grain yield of each plot was obtained after cutting its whole crop with a harvester.

Variance and correlation techniques were used to analyze the data. Differences between means were compared by using the Least Significance Difference test (STEEL and TORRIE 1982).

Results and Discussion

Grain yield and yield components

Grain yield, grain weight per plant and yield components (with the exception of the number of spikelets per spike) were significantly diminished by the forage removal, especially after two cuttings (Table 1). Thus, grain yield declined by 18.4 % and 49.0 % in relation to the uncut controls, following one or two forage removals, respectively. Similar results appear for grain weight per plant (Table 1), which was reduced by 28.0 % and 43.3 % after the same treatments. These reductions in grain yield after forage removal agree closely with those recorded for triticale (POYSA 1985), rye (KILCHER 1982) and winter wheat (DUNPHY et al. 1982), in relation to the number and date of the cuttings.

The number of spikes per plant significantly declined in relation to the number of cuttings (Table 1). The number of spikes per m^2, however, diminished only after two successive cuttings (Table 1), indicating that the lower number of tiller-bearing spikes after one cutting was offset by higher plant survival, probably, as pointed out by YOUNGNER (1972), due light penetrating more deeply into the crop than in uncut controls. This, however, contrasts with reports stating that cutting does not affect (SHARROW and MOTAZEDIAN 1987) or reduce (SHARROW 1990) the number of plants per m^2.

The number of spikelets per spike was not significantly affected by the treatments (Table 1), because spikelet differentiation had ended before the cuttings, but the number of kernels per spikelet (floral fertility) was slightly reduced to the same extent by either one or two cuttings (Table 1). As a result, the number of kernels per spike declined significantly after the treatments (Table 1). Forage removal significantly reduced average weight per kernel, with the treatment of only one cutting showing the minimum values (Table 1). Similar responses in yield components after forage removal have been reported in winter wheat (DUNPHY et al. 1982, SHARROW 1990) and fall-planted rye (KILCHER 1982), although there have also been reports of significant increases in the yield components of winter wheat after grazing (SHARROW and MOTAZEDIAN 1987).

To investigate further how grain yield is affected, linear correlations were calculated between grain production and the yield components listed in Table 1. These correlation coefficients (Table 2) showed a strong correlation between grain production and both the number of spikes per m^2 and the number of spikes per plant, the two yield components most affected by the cuttings. The remaining yield components had less influence on grain yield. Grain weight per plant (Table 2) shows a high degree of correlation between both spikes

Table 1. Grain yield and yield components in relation to the number of cuttings in triticale

Treatment	Grain yield (kg/100 m^2)	Grain per plant (g)	Spikes per m^2 (no.)	Spikes per plant (no.)	Spikelets per spike (no.)	Kernels per spikelet (no.)	Kernels per spike (no.)	Weight per kernel (g)
C_0	95.8 a	8.50 a	475 a	3.33 a	22.3 a	2.34 a	52.0 a	48.9 a
C_1	78.2 b	6.12 b	477 a	2.80 b	22.5 a	2.16 b	48.5 ab	44.9 c
C_2	48.9 c	4.82 c	327 b	2.30 c	21.5 a	2.11 b	45.5 b	46.6 b

a—c: Averages followed by the same letter within a column do not differ at the P = 0.05 probability level using the LSD test.

Table 3. Grain yield and yield components in the main stem and averages for tillers

Treatment	Weight of grain (g)	Spikelets per spike (no.)	Kernels per spikelet (no.)	Kernels per spike (no.)	Weight per kernel (g)	Spike length (cm)
			Main stem			
C_0	2.70 a	23.0 a	2.24 a	51.3 a	52.6 a	11.3 a
C_1	2.35 b	23.7 a	2.17 a	51.0 a	46.1 c	11.2 a
C_2	2.48 b	22.9 a	2.23 a	50.5 a	49.3 b	11.0 a
			Averages for tillers			
C_0	2.51 a	21.8 a	2.33 a	50.4 a	49.4 a	10.8 a
C_1	1.87 b	21.1 a	1.93 b	40.5 b	46.1 b	10.3 b
C_2	1.49 c	19.2 b	1.69 c	32.5 c	45.9 b	9.3 c

a—c: Averages followed by the same letter within a column do not differ at the P = 0.05 probability level using the LSD test.

per plant and kernels per spike, with the remaining components of yield having less influence on grain-yield variation. In addition, a close relationship was shown between the number of kernels per spikelet and kernels per spike, as well as between spikes per plant and spikes per m^2. The other relationships were less importants (Table 2).

Tiller evolution

The number of spikes per m^2, the main determinant of the variations in grain yield, as discussed before, results from both the number of tillers produced by the plant and the percentage of these that survive to form a viable spike. Figure 1 shows the evolution of the number of tillers per m^2 during crop development. While one cutting did not significantly modify the number of tillers per m^2, two successive cutting sharply increased the number of tillers because of the regrowth of a certain number of dormant buds. The survival ability of these later tillers, however, was very limited, resulting in fewer tillers with spikes at harvest in comparison with controls. While there are frequent reports of lower numbers of reproductive tillers at harvest, caused by cutting treatments in wheat (AASE and SIDDOWAY 1975, DUNPHY et al. 1982, BRIGNALL et al. 1988), there are also reports in which the number of spikes was not affected by forage removal when growing conditions were favorable after grazing (SHARROW and MOTAZEDIAN 1987).

Grain production in the main stem and tillers

Grain yield and yield components, when evaluated separately for the main stem and tillers (Table 3), indicated that, in the spike of the main stem, forage removal did not seem to affect either the number of spikelets per spike or the number of kernels per spikelet. In contrast, mean weight per kernel was significantly reduced after one or two forage removals, with the C_1 treatment showing the minimum value. This latter effect caused the grain weight of the main stem to be significantly lower, but without statistical differences between one and two cuttings. The length of the spike of the main stem was not affected by the forage removal.

In tiller averages (Table 3), treatments significantly reduced not only the grain production, but also the number of kernels per spike, the floral fertility, and the spike length. The number of spikelets per spike declined only after two treatments. Mean weight per kernel from the tillers (as opposed to the main-stem kernels), was reduced to the same extent by one or two cuttings.

Biomass and leaf area accumulation

An important property of cereals grown for forage as well as for grain is their regrowth

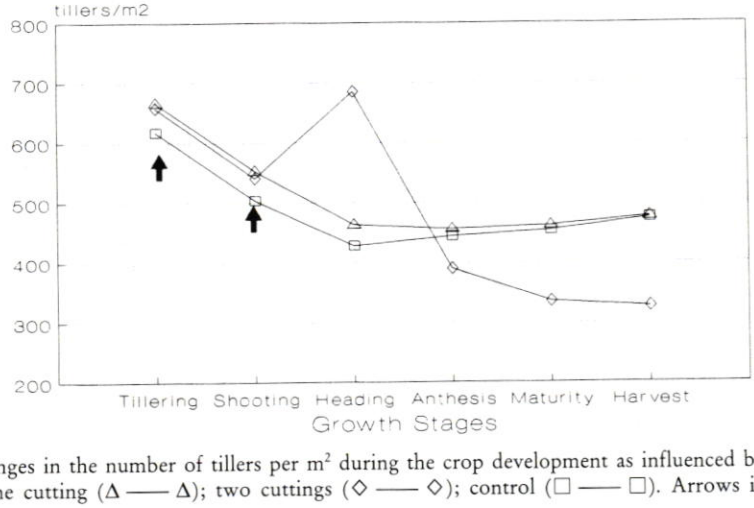


Fig. 1. Changes in the number of tillers per m^2 during the crop development as influenced by one or two cuttings: one cutting (Δ —— Δ); two cuttings ($\Diamond$ —— $\Diamond$); control ($\Box$ —— $\Box$). Arrows indicate treatments

ability after grazing. Several studies have shown that the quantity and metabolic activity of the leaf tissue remaining after cutting is an important factor in subsequent regrowth (MILTHORPE and DAVIDSON 1966; DAVIES 1974). In this study, cuttings significantly diminished the Crop Dry Weight at anthesis (CDWa, Table 4) by 18.3 % and 68.2 % in relation to controls, after one or two cuttings, respectively. Leaf Area Index at anthesis (LAIa, Table 4) was similarly reduced by the forage removal by mean values of 19.6 % and 64.6 % in relation to controls. The LAI at maturity (LAIm, Table 4) was significantly reduced only after two successive cuttings, showing mean reductions of 8.9 % and 60.5 % for one or two cuttings, respectively. Because of these reductions, the Leaf Area Duration (LAD) between anthesis and maturity (Table 4) also significantly diminished by 14.1 % and 57.1 %, respectively. Grain : Leaf Ratio (G), however, significantly increased after the forage removal (Table 4), probably due to better light penetration through the canopy following the reduction in the LAIa.

These results agree with those of DUNPHY et al. (1984) that wheat forage removal decreases the total dry matter and the LAIa, and the LAD from anthesis to maturity. Our results show a highly significant inverse relationship ($r = -0.904^{***}$, $n = 24$) between the final grain yield and the percent of loss in LAIa (in relation to uncut controls) in the plots that had been cut once or twice (Fig. 2). This is consistent with other findings that indicate that grain yield in cereals subjected to cutting is highly dependent upon the ability of the plant to rapidly produce new leaves (DUNPHY et al. 1984, WINTER and THOMPSON 1987). A vigorous regeneration of the leaf area is necessary to provide the photosynthetic capacity required by maximum grain yields. This implies that managing triticale for dual purposes requires consideration not simply for the stage of the

Table 2. Correlation coefficients between grain production and its components

	Grain yield	Weight per kernel	Kernels per spike	Kernels per spikelet	Spikelets per spike	Spikes per plant	Spikes per m^2
Grain/plant	0.715***	0.469**	0.689***	0.366*	0.511**	0.848***	0.533***
Spikes/m^2	0.823***	−0.086	0.353*	0.249	0.154	0.727***	—
Spikes/plant	0.806***	0.197	0.422*	0.265	0.254	—	
Spikelets/spike	0.101	0.563***	0.294	−0.361*	—		
Kernels/spikelet	0.415*	−0.371	0.777***	—			
Kernels/spike	0.457***	−0.047	—				
Kernel weight	0.142	—					

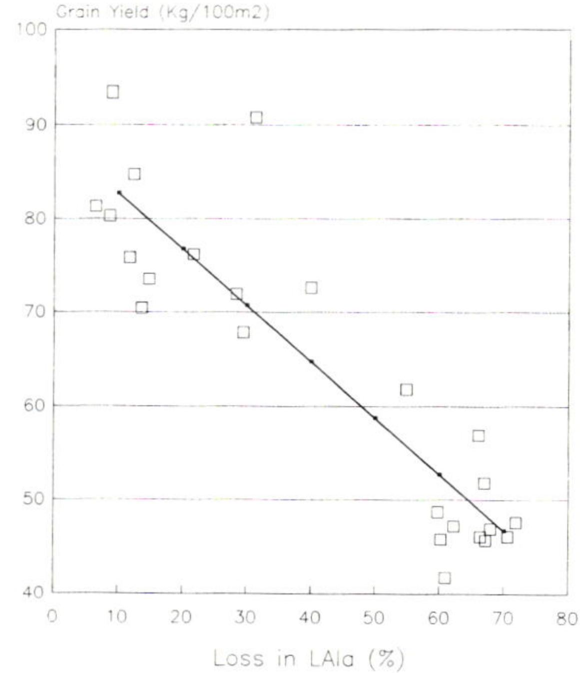
*,**,*** Significant at the 0.05, 0.01 and 0.001 probability levels, respectively (n = 36).

Table 4. Mean values of growth indexes at anthesis and maturity

Treatment	Anthesis		Maturity		
	Crop dry weight (g/m^2)	Leaf area index (m^2/m^2)	Leaf area index (m^2/m^2)	Leaf area duration (weeks)	Grain : leaf ratio ($g/m^2 \cdot wk$)
C_0	1883 a	6.15 a	1.57 a	16.3 a	59.5 a
C_1	1539 b	4.95 b	1.43 a	14.0 b	56.9 a
C_2	599 c	2.18 c	0.62 b	7.0 c	71.6 b

a—c: Means followed by the same letter within a column do not differ at the P = 0.05 probability level using the LSD test.

Fig. 2. Relationship and correlation between grain yield and percent of loss in the Leaf Area Index at anthesis (Y = −0.6 % LAIa + 88.7; r = −0.904***, n = 24)



cutting but also for the regrowth capacity of the cultivar to be used.

Leaf area components

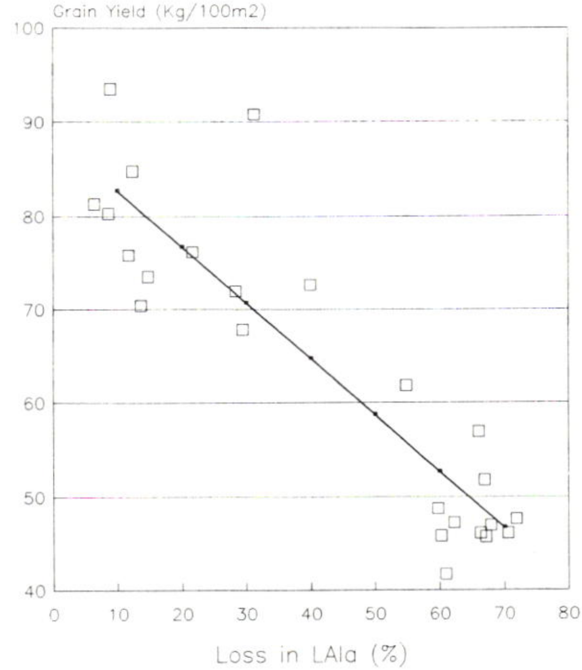
In order to analyze further the influence of forage removal on LAI, leaf area was divided into its components, both at anthesis and at maturity (Table 5). Differences in LAIa were found to be the result of variations in the number of leaves per plant (caused by statistical differences in the number of tillers and in the number of leaves per tiller) as well as in the leaf area per plant, due mainly to reductions in the leaf area per tiller and in the green surface per leaf. Similar results have been reported by

Table 5. Mean values of components of Leaf Area Index at anthesis and maturity

Treament	Tillers per plant (no.)	Leaves per tiller (no.)	Leaves per plant (no.)	Green area per leaf (cm^2)	Leaf area per plant (cm^2)	Leaf area per tiller (cm^2)	Plants per m^2 (no.)
				Anthesis			
C_0	3.1 a	4.3 a	13.0 a	33.9 a	437.6 a	143.1 a	141 b
C_1	2.9 ab	3.4 b	9.8 b	30.6 b	296.7 b	102.3 b	168 a
C_2	2.7 b	2.7 c	7.5 c	21.4 c	158.8 c	58.3 c	138 b
				Maturity			
C_0	3.2 a	1.4 a	4.6 a	25.7 a	118.3 a	36.8 a	134 b
C_1	2.7 b	1.4 a	3.8 b	23.5 a	89.2 b	33.6 a	161 a
C_2	2.1 c	1.2 a	2.6 c	19.9 b	47.3 c	22.2 b	131 b

a—c: Means followed by the same letter within a column do not differ at the P = 0.05 probability level using the LSD test.

Fig. 2. Relationship and correlation between grain yield and percent of loss in the Leaf Area Index at anthesis (Y = −0.6 % LAIa + 88.7; r = −0.904***, n = 24)



cutting but also for the regrowth capacity of the cultivar to be used.

Leaf area components

In order to analyze further the influence of forage removal on LAI, leaf area was divided into its components, both at anthesis and at maturity (Table 5). Differences in LAIa were found to be the result of variations in the number of leaves per plant (caused by statistical differences in the number of tillers and in the number of leaves per tiller) as well as in the leaf area per plant, due mainly to reductions in the leaf area per tiller and in the green surface per leaf. Similar results have been reported by

Table 5. Mean values of components of Leaf Area Index at anthesis and maturity

Treament	Tillers per plant (no.)	Leaves per tiller (no.)	Leaves per plant (no.)	Green area per leaf (cm^2)	Leaf area per plant (cm^2)	Leaf area per tiller (cm^2)	Plants per m^2 (no.)
				Anthesis			
C_0	3.1 a	4.3 a	13.0 a	33.9 a	437.6 a	143.1 a	141 b
C_1	2.9 ab	3.4 b	9.8 b	30.6 b	296.7 b	102.3 b	168 a
C_2	2.7 b	2.7 c	7.5 c	21.4 c	158.8 c	58.3 c	138 b
				Maturity			
C_0	3.2 a	1.4 a	4.6 a	25.7 a	118.3 a	36.8 a	134 b
C_1	2.7 b	1.4 a	3.8 b	23.5 a	89.2 b	33.6 a	161 a
C_2	2.1 c	1.2 a	2.6 c	19.9 b	47.3 c	22.2 b	131 b

a—c: Means followed by the same letter within a column do not differ at the P = 0.05 probability level using the LSD test.

DAVIES (1974) for perennial ryegrass, in which cutting seemed to affect more the width than the length of the new leaves.

At maturity, however, while foliage reduction continued to affect the number of tillers and leaves per plant (Table 5), the changes in leaf area per plant caused by one or two forage removals were mainly due to variations in the number of leaves per plant and in the green area per leaf. Variations in the number of leaves per tiller were not significant (Table 5). The number of plants per m^2 both at anthesis and maturity was significantly higher in the treatments that include one cutting (Table 5), indicating a higher survival of plants, as discussed before.

Conclusion

The data presented here suggest that forage removal in triticale grown under irrigation decreases final grain yield mainly due to a reduction in the number of tillers with spikes at harvest. Whereas foliage reduction does not affect the number of spikelets per spike, kernels per spike, or floral fertility in the mainstem spike, these yield components drastically diminish in the spikes of tillers. Cutting affected mean weight per kernel approximately to the same extent in the main stem as in the tillers. The strong inverse relationships found between the leaf area lost at anthesis and final grain production largely support the suggestion made by DUNPHY et al. (1984) that grain yield in cereals after forage removal depends in large part on the development of new leaf area during the period preceding anthesis. For this reason, the main features in the new triticales developed for the dual purposes of forage and grain production should be a higher capacity for tiller survival and for leaf-area development in the weeks immediately after forage removal.

Zusammenfassung

Blattfläche, Kornertrag und Ertragskomponenten nach einer Futternutzung von Triticale

Triticale (× *Triticosecale* Wittmack) ist ein Getreide, das sowohl für die Futter- als auch Kornerzeugung genutzt werden kann; es besteht aber noch Mangel an Informationen bezüglich der Auswirkungen einer Futternutzung auf die Kornproduktion. Daher wurde der Einfluß von einem Schnitt oder zwei aufeinanderfolgenden Schnitten (als Simulation einer Beweidung) hinsichtlich des Kornertrages, der Ertragskomponenten des Haupthalms und der Bestockungshalme, der Blattfläche und der Biomasseentwicklung bei vier hexaploiden Triticale-Typen, die unter Bewässerung auf einem Standort mit hoher Bodenfruchtbarkeit angebaut wurden, untersucht. Die Futternutzung reduzierte den Kornertrag und das Korngewicht/Pflanze proportional zur Anzahl der Schnitte, wobei überwiegend die Anzahl der ährentragenden Bestockungstriebe zum Zeitpunkt der Ernte vermindert war. Als Folge der Futternutzung waren an der Ähre des Hauptsprosses die Anzahl der Ährchen/Ähre, die Anzahl der Körner/Ähre oder die Fruchtbarkeit der Blüten nicht reduziert; bei den Bestockungstrieben fand sich dagegen eine deutliche Minderung in diesen Ertragskomponenten. Futternutzung beeinflußte das durchschnittliche Korngewicht annähernd in gleichem Ausmaß für Hauptsproß und Bestockungstriebe. Der Blattflächenindex (LAI) zum Zeitpunkt der Blüte zeigte einen signifikanten Rückgang als Folge des Schnitts, wobei überwiegend die Anzahl der Blätter/Pflanze und die Grünfläche/Blatt zurückgingen. Hieraus resultierte eine Abnahme der Blattflächendauer (LAD) vom Zeitpunkt der Blüte bis zur Reife. Es wurde eine straffe gegenläufige Beziehung zwischen dem Prozentsatz des Verlustes an LAI zum Zeitpunkt der Blüte und dem Kornertrag gefunden; hieraus wird geschlossen, daß der Kornertrag überwiegend von der Fähigkeit der Pflanzen bestimmt wird, neue Blattmasse rasch in der Zeit nach dem Schnitt und der Blüte zu entwickeln.

Acknowledgements

The author wishes to gratefully acknowledge the help of B. MARTÍNEZ-OCHOA in obtaining primary values, and Dr. J. MARINETTO and A. FERNANDEZ-CONEJO (CIDA, Granada) for technical assistance with the field experiment, and DAVID NESBITT for assistance with the English version of the text.

References

AASE, J. K., and F. H. SIDDOWAY, 1975: Regrowth of spring-clipped winter wheat in the northern Great Plains of the United States. Can. J. Plant Sci. **55,** 631—633.

BRIGNALL, D. M., M. R. WARD, and W. J. WITTINGTON, 1988: Yield and quality of triticale cultivars at progressive stages of maturity. J. agr. Sci., Camb. **111,** 75—84.

DAVIES, A., 1974: Leaf tissue remaining after cutting and regrowth in perennial ryegrass. J. agr. Sci., Camb. **82,** 165—172.

DAY, A. D., R. K. THOMPSON, and W. F. MCCAUGHEY, 1968: Effects of clipping on the performance of spring barley (*Hordeum vulgare* L. emend Lam) seeded in October. Agron. J. **60,** 11—12.

DUNPHY, D. J., M. E. MCDANIEL, and E. C. HOLT, 1982: Effect of forage utilization on wheat grain yield. Crop Sci. **22,** 106—109.

— —, E. C. HOLT, and M. E. MCDANIEL, 1984: Leaf area and dry matter accumulation of wheat following forage removal. Agron. J. **76,** 871—874.

HYDER, D. N., 1972: Defoliation in relation to vegetative growth. In: V. B. YOUNGNER and C. M. MCKELLT (eds.), The Biology and Utilisation of Grasses, pp. 305—316. Academic Press, London.

KILCHER, M. R., 1982: Effect of cattle grazing on subsequent grain yield of fall rye (*Secale cereale* L.) in southwestern Saskatchewan. Can. J. Plant Sci. **62,** 795—796.

MILTHORPE, F. L., and J. L. DAVIDSON, 1966: Physiological aspects of regrowth in grasses. In: F. L. MILTHORPE and J. D. IVINS (eds.), The Growth of Cereals and Grasses, pp. 241—255. Butterworths, London.

POYSA, V. H., 1985: Effect of forage harvest on grain yield and agronomic performance of winter triticale, wheat and rye. Can. J. Plant Sci. **65,** 879—888.

RAMOS, J. M., L. F. GARCÍA DEL MORAL, and L. RECALDE, 1982: The influence of pre- and post-anthesis periods on yields of winter barley varieties in southern Spain. J. agric. Sci., Camb. **99,** 521—523.

— —, — —, and — —, 1985: Vegetative growth of winter barley in relation to environmental conditions and grain yield. J. agric. Sci., Camb. **104,** 413—419.

SHARROW, S. H., 1990: Defoliation effects on biomass yield components of winter wheat. Can. J. Plant Sci. **70,** 1191—1194.

— —, and I. MOTAZEDIAN, 1987: Spring grazing effects on components of winter wheat yield. Agron. J. **79,** 502—504.

STEEL, R. G. D., and J. H. TORRIE, 1982: Principles and procedures of statistics. A biometrical approach. 2nd edition. McGraw-Hill, New York, 631 p.

TOTTMAN, D. R., and R. J. MAKEPEACE, 1979: An explanation of the decimal code for the growth stages of cereals, with illustrations. Ann. appl. Biol. **93,** 221—234.

WINTER, S. R., and E. K. THOMPSON, 1987: Grazing duration effects on wheat growth and grain yield. Agron. J. **79,** 110—114.

YOUNGNER, V. B., 1972: Physiology of defoliation and regrowth. In: V. B. YOUNGNER and C. M. MCKELLT (eds.), The Biology and Utilisation of Grasses, pp. 292—303. Academic Press, London.