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The relation of maturity to total yield and seasonal distribution of yield in orchardgrass (Dactylis glomerata L.)

A. J. Hester

To the Graduate Council:

I am submitting herewith a thesis written by A. J. Hester entitled "The relation of maturity to total yield and seasonal distribution of yield in orchardgrass (Dactylis glomerata L.)." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

Elmer Gray, Major Professor

We have read this thesis and recommend its acceptance:

Edward E.C. Clebsch, Calvin O. Qualset

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(Original signatures are on file with official student records.)

May 18, 1966

To the Graduate Council:

I am submitting herewith a thesis written by A. J. Hester entitled "The Relation of Maturity to Total Yield and Seasonal Distribution of Yield in Orchardgrass (Dactylis glomerata L.)." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

Elmer Gray
Major Professor

We have read this thesis and recommend its acceptance:

Calvin O. Qualset

Edward E.C. Clebsch

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

THE RELATION OF MATURITY TO TOTAL YIELD AND SEASONAL DISTRIBUTION OF YIELD IN ORCHARDGRASS (*DACTYLIS GLOMERATA* L.)

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

A. J. Hester

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Orchardgrass (*Dactylis glomerata* L.) is grown in the United States from the Canadian border to the northern parts of the Gulf states (8). Although Tennessee is near the southern boundary of orchardgrass adaptation, it ranks seventh among the states with 265,000 acres. Yields of orchardgrass per acre tend to be lower near the southern boundary of its adaptation.

Seasonal distribution of orchardgrass production is not uniform. In Tennessee the most rapid growth occurs in the spring and early summer. Rate of growth is slow in late summer and then increases in the fall. It would be desirable to have an orchardgrass which would produce more during late summer.

Orchardgrass is often grown in association with perennial legumes such as alfalfa. Since the orchardgrass varieties grown in Tennessee mature earlier than these legumes, it is difficult to get maximum yields of high quality forage from orchardgrass-legume mixtures. A later maturing variety of orchardgrass is needed.

The objective of this study was to determine the relationship in orchardgrass of maturity (time of anthesis) to total season production and seasonal distribution of production.

CHAPTER II

REVIEW OF LITERATURE

I. DESCRIPTION OF ORCHARDGRASS

Orchardgrass is a long-lived cool season perennial forage grass (18). It forms an open sod making it a good companion crop for legumes. The plant has an extensive root system. The flowering culms are from 2 to 4 feet tall. The orchardgrass inflorescence is a panicle with spikelets in dense clusters at the end of a few, stiff branches (8). Orchardgrass starts growth early in the spring and develops rapidly. Maturity is somewhat earlier than bromegrass and about three weeks earlier than timothy (17).

Dactylis glomerata L. has four sets of seven chromosomes (13). Muntzing (13) in 1937 suggested that the tetraphloid orchardgrass originated from the doubling of the chromosome number in D. glomerata L. ssp aschersoniana (Graebner) Thellung. Myers (15) in 1948 reported distinguishable differences between D. glomerata and induced tetraploids of D. glomerata L. ssp. aschersoniana. He obtained a diploid Dactylis glomerata L. ssp. woronowii (Ovczinn) Stebbins et Zohary plant from Iran that was cross fertile with D. glomerata L. ssp. aschersoniana. The hybrid of these two subspecies had many characteristics in common with D. glomerata. He suggested that this may have been the origin of orchardgrass. Stebbins and Zohary (17) in 1959 concluded that orchardgrass most likely originated from a hybrid between the subspecies aschersoniana and woronowii or between the subspecies aschersoniana and Dactylis glomerata L. Reichenbachii (Hausm.) Stebbins et Zohary.

II. MATURITY AND YIELD IN ORCHARDGRASS

It appears that maturity of a species and of plants within a species is governed by a number of interactions involving genotype and environment. Of the environmental factors, photoperiod and temperature are of major importance. The interaction of these factors depends on the combination of environmental conditions prevailing in the native habitat of the species or ecotype (7).

Plant breeders have experienced as much success in modifying time of maturity as in modifying most other characteristics (7). Kalton et al. (10) reported significant correlation coefficients for date of maturity in orchardgrass of parents and inbred progenies that ranged from .35 to .42. Hanson (7) found evidence that time of maturity in orchardgrass is controlled by a relatively small number of major genes.

The inheritance of maturity has been studied in other grass species. Johnson and Paul (9) concluded that two major gene pairs with additive effects and no dominance accounted for most of the maturity variation in segregating barley populations. Cooper (4) concluded that genetic variation in date of ear emergence in Lolium was mostly additive.

Davis (5) reported a range of 16 days in date of maturity among orchardgrass varieties in Canada. Meredith (11) working in New York reported a 21-day range in maturity of six orchardgrass varieties.

Yields of orchardgrass tend to be lower in Tennessee than in the more northern states. Fribourg (6) reported results of orchardgrass variety tests conducted at three locations in Tennessee. Average production in tons dry matter per acre of Boone and Potomac, the two most adapted varieties, is summarized as follows:

	Columbia	Crossville	Knoxville
Boone	2.01	1.87	1.00
Potomac	2.02	1.96	0.95

Fribourg (6) stated that most of the production occurred in spring, early summer and late fall; little growth occurred in midsummer and winter.

Murphy <u>et al</u>. (14) reported that there are opportunities for improvement in total season yield and seasonal distribution of yield in orchardgrass. They stated that late strains usually yield less than those maturing earlier but the difference is reduced by cutting each at a comparable stage of maturity. They suggested that improvements in seasonable distribution of yield might be accomplished by the use of strains formulated from clones whose progenies produce high aftermath yields. If higher aftermath yields were obtained it might be economical to sacrifice some yield in the first harvest. Their data from New York, Pennsylvania and Maryland are summarized in Table 1.

TABLE 1. Maturity and location effects on orchardgrass yields in the northeast.

Maturity	Number of Progenies Included	Average Yield in Tons Dry Matter Per Acre at 12 Percent Moisture					
		New York		Pennsylvania		Maryland	
		Total Season	Total Aftermath	Total Season	Total Aftermath	Total Season	Total Aftermath
N. E. 28 Group							
Early	22	3.78	1.98	3.41	1.74	2.24	0.76
Medium	22	3.65	1.73	3.59	1.79	2.51	0.89
Late	22	3.27	1.36	2.88	1.26	1.99	0.64
N. E. 10 Group							
Early	17	4.44		2.62			
Medium	15	4.32		2.39			
Late	10	4.04		2.43			

Late maturing progenies were lowest in both aftermath and total season production in the three states. The relative performance of the early and late maturing progenies were not consistent. Using these data and those reported by Fribourg (6) the increasing order of total yields by states was Tennessee, Maryland, Pennsylvania and New York.

Davis (5) found that early maturing varieties tend to be higher in total yield. Similar results were obtained by Van Keuren (18).

When late season distribution was considered, Van Keuren (19) found that late maturing varieties had higher yields than early maturing varieties. Davis (5) used 40 orchardgrass varieties and classified them into five maturity groups. He ranked maturity groups for yields of dry matter production as follows:

Cutting period	Maturity groups in descending order of yield of dry matter
May-June	Very early > very late > early > medium > late
June-July	Medium > very early > early = very late > late
July-August	Medium > early = very late > very early = late
August-September	Medium = early > late > very late > very early
September-October	Medium > early > late > very late = very early

III. QUALITY OF ORCHARDGRASS

Palatability and nutritive value decline rapidly with approaching maturity (8). When orchardgrass is grazed or clipped frequently, the quality of the forage is considered to be quite good. One of the most common errors in management of orchardgrass is allowing it to become too mature before grazing or clipping for hay.

Meredith (11) studied the relationship between maturity, dry matter percentage and percent digestible dry matter. He found a positive correlation between dry matter percentage and stage of maturity ($r = .967$) and a negative correlation between dry matter percentage and digestible dry matter ($r = -.818$). He reported that the decline in digestible dry matter of first harvest forage was slower for late maturing varieties than for early ones. He also showed that time of maturity, not date of harvest, was the best predictor of digestible dry matter for orchardgrass. Homb, as reported by Meredith (11), found a high correlation for dry matter percentage and stage of maturity in timothy and red clover. He further showed a high positive correlation between stage of maturity and digestible organic matter, but made no attempt to show a relation between dry matter percentage and digestible organic matter.

Reid *et al*. (16) reported a correlation coefficient of -.80 for dry matter percentage and digestible dry matter in 28 forage species. A 1 percent increase in dry matter percentage resulted in approximately 1 percent decrease in digestibility. They also reported that in the northeastern region of the United States the date of harvest rather than the stage of growth was the major determinant of digestibility in first cut forages.

Mourat *et al*. (12) studied two early maturing clones and two late maturing clones of orchardgrass. Both of the early clones were significantly more digestible than either of the late maturing clones at both the vegetative and heading stage. In all four clones the digestibility declined more than 20 percent from vegetative to early seed stage.

Clarke (3) reported a very sharp decline in carotene content between the vegetative stage and inception of heading in orchardgrass with a slower decline between heading and anthesis. Protein content varied in much the same way as carotene content. He pointed out that late maturing clones were slightly lower in both carotene and protein at all stages of growth than early maturing clones.

Davis (5) reported a highly significant negative correlation for date of maturity to yield of protein in orchardgrass. He stated that, in general, total yield of dry matter was higher in the early maturing clones and was the main determinant of protein yield.

Archibald *et al.* (1) compared the palatability of nine varieties from eight species and found that cattle showed a definite preference for species of forage that were low in dry matter percentage.

CHAPTER III

MATERIALS AND METHODS

The 19 clones included in this study were from various states in the Southeast (Table 2). These clones were chosen for their wide range in time of maturity.

The clones were transplanted at the Plant Science Farm, Knoxville, Tennessee, October 4, 1963 into an Etowah silt loam soil. Clones were broken into small clumps and planted in a randomized complete block design with four replications. Each entry consisted of an eight-plant clonal row. The plants were spaced one foot apart in rows that were three feet apart.

The area was fertilized according to soil test recommendations at the time of planting. Maintenance fertilizer consisted of 600 lbs. per acre of 10-10-10 in the spring with an additional 30 lbs. of N per acre applied to an entry each time it was harvested. Yield data were collected in 1964 and 1965. The first harvest was taken when one-half of the plants of a clone reached anthesis and subsequent harvests were made when the average height of a clone reached 15 inches. The plants were cut back to approximately four inches at each harvest. Regardless of height, all entries were harvested at the middle of September in both years. Harvesting was done with a hand sickle.

The two end plants in each row were discarded and the six remaining plants were weighed, dried at 70°C. and weighed again. Dry

TABLE 2. Identification of 19 orchardgrass clones.

Clone Number	Clone Identification: Origin	Clone Identification: Field Entry Number
1	N. C. 7	01
2	Pa. MIII-8	02
3	Ky. 2-51	19
4	Ky. 1-73	20
5	Pa. 52-114	05
6	Ark. 36	03
7	S. C. 12	06
8	Va. 57-29	04
9	Pa. MIII-20	08
10	N. C. 5	14
11	N. C. 2	09
12	S. C. 13	11
13	Va. 57-216	07
14	N. C. 3	17
15	Ky. 2-93	18
16	Va. T. C. 38	10
17	Va. 57-528	12
18	Va. 279	15
19	Va. 113	16

matter weights were used in the statistical analyses.

Anthesis dates and subsequent harvest dates were reported in terms of climate days. March 1 is climate day one and was assumed to be the date of growth initiation.

Analyses of variance were computed on first harvest and total yields for each year and on the average yields for the two years. The Duncan's Multiple Range Test was used to separate means.

CHAPTER IV

RESULTS

I. TOTAL DRY MATTER PRODUCTION

Dates of harvest and yield per harvest for 19 orchardgrass clones are given in Table 3 for 1964 and in Table 4 for 1965. The clones are arranged in the tables by decreasing total season dry matter production. Date of harvest is given on a climate day basis with climate day 1 being March 1.

The range in total dry matter yields was 260 to 868 grams in 1964 and 80 to 469 grams in 1965. The higher yields and greater number of harvests in 1964 may have resulted from climatic conditions or aging of the stand. The amount and frequency of precipitation are given in Tables 5 and 6 for 1964 and 1965, respectively. The total precipitation between April 1 and September 15 amounted to 19.30 inches in 1964 and 17.31 inches in 1965. In 1964 the summer dry period began about the first of June and continued until about mid-August. In 1965 a dry period occurred in the early part of May. Since most of the orchardgrass production comes in the early spring, the earlier dry period in 1965 than in 1964 may have been partly responsible for the lower yields. A general observation has been that with vegetative propagation the plants have been more vigorous in the first year than in successive years following establishment.

TABLE 3. Harvest dates and dry matter yields (grams) of 19 orchardgrass clones in 1964.

	1st Harvest		2nd Harvest		3rd Harvest		4th Harvest		5th Harvest		6th Harvest		7th Harvest		8th Harvest		9th Harvest		Total Season Production
Clone	Yield	Climate Day	Yield	Climate Day	Yield	Climate Day	Yield	Climate Day	Yield	Climate Day	Yield	Climate Day	Yield	Climate Day	Yield	Climate Day	Yield	Climate Day	
13	610[1]	79	40	87	66	99	40	134	54	151	22	166	37	197					869a*
12	458	75	39	85	43	95	37	106	64	143	40	157	22	173	37	197			740 b
7	362	68	52	75	40	82	58	93	43	103	68	143	59	157	51	197			733 bc
9	466	71	42	80	65	93	47	103	38	151	27	197							685 bcd
6	350	68	44	75	33	82	42	93	35	103	68	143	37	157	32	178	22	197	663 bcd
11	418	75	38	82	21	87	46	99	66	143	26	157	17	197					632 cde
17	430	82	43	93	51	103	31	145	20	157	16	197							591 def
15	351	79	31	87	51	99	60	143	26	166	31	197							550 efg
8	310	71	45	80	32	87	40	99	67	143	25	166	21	197					540 efgh
4	273	68	37	75	40	85	40	95	28	117	50	151	20	173	24	197			512 fgh
10	293	71	32	80	43	93	32	103	41	145	25	157	22	178	16	197			504 fgh
18	318	85	59	99	65	143	28	166	29	197									499 fgh
1	255	68	30	75	24	82	33	93	25	103	32	145	25	157	20	178	18	197	461 ghi
2	250	68	40	75	49	85	38	95	29	106	22	152	14	197					442 hij
5	221	71	22	80	32	93	60	152	51	197									386 ijk
14	237	79	30	93	26	117	29	152	25	197									347 jk
3	140	68	25	75	29	85	34	96	33	117	39	151	12	173	10	197			322 k
16	185	82	38	93	31	106	42	151	23	197									319 k
19	184	99	50	151	16	197													250 k

*Duncan's Multiple Range Test at .05 level of probability.

[1]Each yield is an average of four six-plant rows.

TABLE 4. Harvest dates and dry matter yields (grams) of 19 orchardgrass clones in 1965.

Clone	1st Harvest Yield	1st Harvest Climate Day	2nd Harvest Yield	2nd Harvest Climate Day	3rd Harvest Yield	3rd Harvest Climate Day	4th Harvest Yield	4th Harvest Climate Day	5th Harvest Yield	5th Harvest Climate Day	6th Harvest Yield	6th Harvest Climate Day	Total Season Production
13	234[1]	81	46	91	77	105	58	127	43	157	12	198	470a*
17	190	88	80	105	70	121	50	151	6	198			396ab
9	194	79	27	91	44	107	40	127	35	156	10	198	350abc
12	182	79	30	93	44	107	38	127	28	156	12	198	334 bcd
7	159	79	38	93	42	109	55	157	10	198			304 bcde
1	133	70	31	91	37	107	27	121	42	151	16	198	286 bcdef
18	173	105	48	121	41	151	12	198					274 bcdefg
10	92	81	38	95	36	109	48	134	26	156	16	198	256 cdefg
6	97	79	31	93	70	114	42	157	8	198			248 cdefgh
16	54	81	36	95	68	114	43	198					201 defghi
4	59	73	32	91	38	109	46	156	14	198			189 efghi
2	50	70	38	95	55	114	20	198					163 fghi
3	51	70	24	93	24	107	26	127	25	156	11	198	161 fghi
5	45	73	62	121	36	157	14	198					157 fghi
15	68	81	20	93	48	114	8	198					144 ghi
8	76	79	23	91	28	107	14	198					141 ghi
11	58	79	26	109	23	156	2	198					109 hi
19	86	114	6	198									92 i
14	52	81	28	198									80 i

*Duncan's Multiple Range Test at .05 level of probability.

[1] Each yield is an average of four six-plant rows.

TABLE 5. Precipitation (inches) between April 1 and September 30, 1964.

Day	April	May	June	July	August	September
1			.85			
2	.03		.05	.03		
3	.01	.74			.33	
4	.39				.87	
5	.30					
6	.47		.18			
7	1.92		.01		.02	
8	.04			.76		
9						
10				.06		
11					.20	
12	.01	.41		.60	.01	
13	.26	.24		.26		
14	1.01	.02	.04			
15					.39	
16			.27	.07	2.90	
17						
18			.02		.30	.75
19						.50
20					.29	
21						
22					.05	
23	.20					
24	1.09	.07	.25	.02		
25	.26					
26	.10			.37		
27	.37	.29				
28		.17				
29	.08	1.03			.06	1.22
30				.20	.33	.35
31						

TABLE 6. Precipitation (inches) Between April 1 and September 30, 1965.

Day	April	May	June	July	August	September
1						.05
2						
3			.15	.10		
4	.28		.39	.06		
5			.03			
6	.05		.04			
7	1.61		.05			
8			.24	1.03	1.05	
9	.15		.29		.04	
10			.21	.24		
11	.16		.19	1.66		.02
12		.53	.43			.91
13			.06			
14						
15	.03		.16			
16	.95		.23	.10		.14
17						
18		.20				.05
19						
20						
21		.03			.04	
22		.32			.14	
23				.47	.09	
24			.20	.28	1.17	1.98
25	.16		.29	.09	.02	.09
26	.12	.11				
27	.42	.83		.09		
28	.11	.50		.06		
29		.02				
30	.01		.05			
31						

There were significant differences among clones in both years. Clone 13 had the highest yield in both years and clones 7 and 9 were also high in both years. Clones 14 and 19 produced low yields in both years. Relative performance of all the clones was not consistent in both years (Table 7). The interaction of clones with years was statistically significant. This interaction may have resulted from different responses of the clones to climatic conditions or the management system.

II. MATURITY VS. TOTAL DRY MATTER PRODUCTION

One aspect of this study was to determine the relationship between date of maturity and total dry matter production. Data are presented in Table 8 for date of maturity and total dry matter production for 1964, 1965 and the average for the two years. The clones are arranged by average date of maturity. Maturity was considered to be the date of anthesis and is reported as climate days. The range in maturity was 31 days in 1964 and 44 days in 1965. High yielding clones were distributed throughout the maturity range for both years. Clone 13 which had the highest yield was near the middle of the maturity range.

Correlation coefficients for date of maturity and total dry matter production were: 1964, $r = -.244$; 1965, $r = -.032$; for the average of the two years, $r = -.183$. None of these values were significant at the .05 level of probability. This indicates no relationship between date of maturity and total dry matter production.

TABLE 7. Rank of 19 orchardgrass clones for total season dry matter production in 1964 and 1965.

Clone	Rank 1964	Rank 1965
1	13	6
2	14	12
3	17	13
4	10	11
5	15	14
6	5	9
7	3	5
8	9	16
9	4	3
10	11	8
11	6	17
12	2	4
13	1	1
14	16	19
15	8	15
16	18	10
17	7	2
18	12	7
19	19	18

TABLE 8. Relationship of maturity to total dry matter production (grams) of 19 orchardgrass clones grown in 1964 and 1965.

Clone	1964 Maturity	1964 Yield	1965 Maturity	1965 Yield	Average Maturity	Average Yield
1	68	461*	70	286	69	374
2	68	442	70	168	69	302
3	68	322	70	161	69	242
4	68	512	73	189	70	351
5	71	386	73	157	72	271
6	68	663	79	248	74	455
7	68	733	79	304	74	518
8	71	540	79	141	75	341
9	71	685	79	350	75	518
10	71	504	81	256	75	380
11	75	632	79	109	76	370
12	75	740	79	334	76	537
13	79	869	81	470	80	668
14	79	347	81	80	80	214
15	79	549	81	144	80	346
16	82	319	81	201	82	260
17	82	591	88	396	85	493
18	85	499	105	274	95	386
19	99	250	114	92	106	171

*Each yield is an average of four six-plant rows.

III. MATURITY VS. DISTRIBUTION OF YIELD

Dates of maturity and grams of dry matter production in the first harvest are presented in Table 9. There were significant differences among clones for first harvest yields in both years and for the two-year average yields. The range was 140 to 610 grams in 1964 and 45 to 234 grams in 1965. The high and low yielding clones in the first harvest were distributed throughout the maturity range. The correlation coefficients for maturity and yield of first harvest were: 1964, $r = -.031$, 1965, $r = -.263$; for the two-year average, $r = .061$. These values indicate no relation between date of maturity and yield of first harvest.

Date of maturity and dry matter production after the first harvest are given in Table 10. Correlation coefficients between these two variables were: 1964, $r = -.136$; 1965, $r = -.335$; for the two-year average, $r = -.509$. Only the correlation coefficient for the two-year average was significant ($P < .05$).

The percentage of the total yield taken in each harvest for 1964 and 1965 is given in Tables 11 and 12, respectively. Date of maturity versus percent of total yield in the first harvest gave r values of .721, .817, and .862 for 1964, 1965 and the average of the two years, respectively. The values were all highly significant ($P < .01$) indicating that as maturity became later there was an increase in the proportion of the total yield obtained in the first harvest.

TABLE 9. Relationship of maturity to dry matter production (grams) of first harvest of 19 orchardgrass clones in 1964 and 1965.

	1964			1965			Average	
Clone	Maturity	Yield	Clone	Maturity	Yield	Clone	Maturity	Yield
13	79	610a*[1]	13	81	234a*	13	80	422a*
9	71	466 b	9	79	194ab	9	75	330 b
12	75	458 b	17	88	190ab	12	76	320 b
17	82	430 bc	12	79	182abc	17	85	310 b
11	75	418 bcd	18	105	173abcd	7	74	260 c
7	68	362 bcde	1	70	133 bcde	18	95	245 cd
15	79	351 bcdef	7	79	159 bcde	11	76	238 cd
6	68	350 bcdef	6	79	97 cde	6	74	223 cd
18	85	318 cdef	10	81	92 cde	15	80	210 de
8	71	310 cdefg	19	114	86 de	1	69	194 def
10	71	293 defg	8	79	76 e	8	75	193 def
4	68	273 efg	15	81	68 e	10	75	192 def
1	68	255 efgh	4	73	59 e	4	70	166 efg
2	68	250 efgh	11	79	58 e	2	69	150 fgh
14	79	237 efgh	16	81	54 e	14	80	144 fgh
5	71	221 fgh	14	81	52 e	19	106	135 gh
16	82	185 gh	3	70	51 e	5	72	133 gh
19	99	184 gh	2	70	50 e	16	82	120 gh
3	68	140 h	5	73	45 e	3	69	96 gh

*Duncan's Multiple Range at .05 level of probability.

[1]Each yield is an average of four six-plant rows.

TABLE 10. Relationship of maturity to dry matter production (grams) of aftermath harvests of 19 orchardgrass clones grown in 1964 and 1965.

	1964		1965		Average	
Clones	Maturity	Yield	Maturity	Yield	Maturity	Yield
1	68	206*	70	153	69	179
2	68	192	70	113	69	152
3	68	182	70	110	69	146
4	68	239	73	130	70	185
5	71	165	73	112	72	138
6	68	313	79	151	74	232
7	68	371	79	145	74	258
8	71	230	79	65	75	148
9	71	219	79	156	75	187
10	71	211	81	164	75	188
11	75	214	79	51	76	133
12	75	282	79	152	76	217
13	79	259	81	236	80	247
14	79	110	81	28	80	69
15	79	198	81	76	80	137
16	82	134	81	147	82	140
17	82	161	88	206	85	183
18	85	181	105	101	95	141
19	99	66	114	6	106	36

*Each yield is an average of four six-plant rows.

TABLE 11. Percentage of total yield in each harvest for 19 orchardgrass clones in 1964.

Clone	Percent of Total Yield								
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
1	55.3	6.5	5.2	7.2	5.4	6.9	5.2	4.3	4.0
2	56.6	9.0	11.1	8.6	6.6	5.0	3.1		
3	43.5	7.8	9.0	10.6	10.2	12.1	3.7	3.1	
4	53.3	7.2	7.8	7.8	5.5	9.8	3.9	4.7	
5	57.2	5.7	8.3	15.5	13.3				
6	52.8	6.6	5.0	6.3	5.3	10.2	5.6	4.8	3.4
7	49.4	7.1	5.4	7.9	5.9	9.3	8.0	7.0	
8	57.4	8.3	5.9	7.4	12.4	4.6	4.0		
9	68.0	6.1	9.5	6.9	5.5	4.0			
10	58.1	6.3	8.5	6.3	8.1	5.0	4.4	3.3	
11	66.1	6.0	3.3	7.3	10.4	4.1	2.8		
12	61.9	5.3	5.8	5.0	8.6	5.4	3.0	5.0	
13	70.2	4.6	7.6	4.6	6.2	2.5	4.3		
14	68.3	8.6	7.5	8.4	7.2				
15	63.8	5.6	9.3	10.9	4.7	5.7			
16	58.0	11.9	9.7	13.2	7.2				
17	72.8	7.3	8.6	5.2	3.4	2.7			
18	63.7	11.8	13.0	5.6	5.9				
19	73.6	20.0	6.4						

TABLE 12. Percentage of total yield in each harvest for 19 orchard-grass clones in 1965.

	Percent of Total Yield					
Clone	1st	2nd	3rd	4th	5th	6th
1	47.2	11.0	11.7	9.6	14.9	5.6
2	30.7	23.3	33.7	12.3		
3	31.7	14.9	14.9	16.1	15.5	6.9
4	31.2	16.9	20.1	24.3	7.5	
5	28.7	39.5	22.9	8.9		
6	39.1	12.5	28.2	16.9	3.3	
7	52.6	12.6	13.9	18.2	2.7	
8	53.9	16.3	19.8	10.2		
9	55.4	7.7	12.6	11.4	10.0	2.9
10	35.9	14.8	14.1	18.8	10.2	6.2
11	53.2	23.8	21.1	1.9		
12	54.5	9.0	13.2	11.4	8.4	3.5
13	49.8	9.8	16.4	12.3	9.1	2.6
14	65.0	35.0				
15	47.2	13.9	33.3	5.6		
16	26.9	17.9	33.8	21.4		
17	48.0	20.2	17.7	12.6	1.5	
18	63.1	17.5	15.0	4.4		
19	93.5	6.5				

Grams of dry matter production per day are given for 1964 in Table 13 and for 1965 in Table 14. These values were determined by dividing the yield by the number of days between a given harvest and the previous harvest. For the first harvest, the yield was divided by the number of days between climate day one and the harvest date. Since plants were allowed to go to the anthesis stage, yields were highest for the first harvest; however, dry matter production per day (assuming that growth began March 1) was not always highest for the first harvest. Production per unit time was higher in the early part of the season than in the latter part as is evident from grams per day (Tables 13 and 14) and from the cumulated production presented in Figures 1 through 4. Dry matter production per day appeared to be independent of maturity. This seemed to be true for first harvest as well as later harvests.

High yielding clones were high because of their greater yields in the first harvest (Figures 1 through 4). The first harvests accounted for 43.5 to 73.6 percent of the total yield of the clones in 1964 and 26.9 to 93.5 percent of the total yield in 1965 (Tables 11 and 12). Correlation coefficients for yields of first harvest and total yields were: 1964, r = .948; 1965, r = .911. Maturity was not related to either yield of first harvest or total yield of the clones.

IV. MATURITY AND DRY MATTER PERCENTAGE

Based on the correlation (r = .818) between dry matter percentages and digestible dry matter of orchardgrass (11), the effects of

TABLE 13. Grams of dry matter production per day for 19 orchardgrass clones in 1964.*

Clone	g./ Day	Climate Day	g./ Day	Climate Day	g./ Day	Climate Day	g./ Day	Climate Day	g./ Day	Climate Day	g./ Day	Climate Day	g./ Day	Climate Day	g./ Day	Climate Day	g./ Day	Climate Day
1	3.75[1]	68	4.21	75	3.39	82	3.02	93	2.29	103	0.75	145	1.98	157	0.96	178	0.95	197
2	3.67	68	5.71	75	4.92	85	3.43	95	2.63	106	0.50	152	0.95	197				
3	2.06	68	3.61	75	2.92	85	3.13	96	1.57	117	1.11	151	0.57	173	0.44	197		
4	4.02	68	5.25	75	3.95	85	3.95	95	1.27	117	1.43	151	0.93	173	1.04	197		
5	3.11	71	2.39	80	2.42	93	1.01	152	1.13	197								
6	5.14	68	6.32	75	4.71	82	3.81	93	3.52	103	1.65	143	2.64	157	1.52	178	1.18	197
7	5.32	68	7.36	75	5.71	82	5.29	93	4.35	103	1.66	143	4.19	157	1.28	197		
8	4.36	71	4.94	80	4.61	87	3.35	99	1.49	143	1.09	166	0.68	197				
9	6.55	71	4.69	80	4.98	93	4.72	103	0.78	151	0.60	197						
10	4.13	71	3.52	80	3.29	93	3.22	103	0.95	145	2.06	157	1.05	178	0.84	197		
11	5.56	75	5.46	82	4.25	87	3.85	99	1.47	143	1.84	157	0.43	197				
12	6.11	75	3.90	85	4.30	95	3.34	106	1.70	143	2.89	157	1.39	173	1.55	197		
13	7.71	79	5.06	87	5.54	99	1.10	134	3.16	151	1.43	166	1.18	197				
14	3.00	79	2.16	93	1.48	117	0.80	152	0.57	197								
15	4.44	79	3.87	87	4.25	99	1.32	143	1.12	166	1.01	197						
16	2.25	82	3.43	93	2.40	106	0.92	151	0.50	197								
17	5.25	82	3.91	93	5.10	103	0.72	145	1.64	157	0.40	197						
18	3.73	85	4.23	99	1.54	143	1.22	166	0.94	197								
19	2.70	99	0.96	151	1.09	197												

*Grams per day was obtained by dividing yield by number of days between harvests.

[1]Each yield is an average of four six-plant rows.

TABLE 14. Grams of dry matter production per day for 19 orchardgrass clones in 1965.*

Clone	g./Day	Climate Day	g./Day	Climate Day	g./Day	Climate Day	g./Day	Climate Day	g./Day	Climate Day	g./Day	Climate Day
1	1.90[1]	70	1.47	91	2.06	107	1.91	121	1.42	151	.33	198
2	0.71	70	1.50	95	2.89	114	.23	198				
3	0.73	70	1.04	93	1.68	107	1.28	127	.87	156	.27	198
4	.81	73	1.80	91	2.14	109	1.03	156	.33	198		
5	.62	73	1.29	121	.99	157	.35	198				
6	1.23	79	2.21	93	3.31	114	.98	157	.20	198		
7	2.01	79	2.68	93	2.62	109	1.20	157	.20	198		
8	.97	79	1.94	91	1.75	107	.16	198				
9	2.46	79	2.27	91	2.72	107	1.98	127	1.22	156	.44	198
10	1.14	81	2.68	95	2.57	109	1.94	134	1.20	156	.39	198
11	.73	79	.87	109	.50	156	.06	198				
12	2.30	79	2.11	93	2.75	107	1.88	127	1.47	156	.28	198
13	2.88	81	4.55	91	5.50	105	2.64	127	1.44	157	.30	198
14	.64	81	.24	198								
15	.84	81	1.62	93	2.26	114	.95	198				
16	.67	81	2.57	95	3.55	114	.97	198				
17	2.15	88	4.68	105	4.36	121	1.67	151	.14	198		
18	1.65	105	2.97	121	1.36	151	.25	198				
19	.75	114	.08	198								

*Grams per day was obtained by dividing yield by number of days between harvests.

[1]Each yield is an average of four six-plant rows.

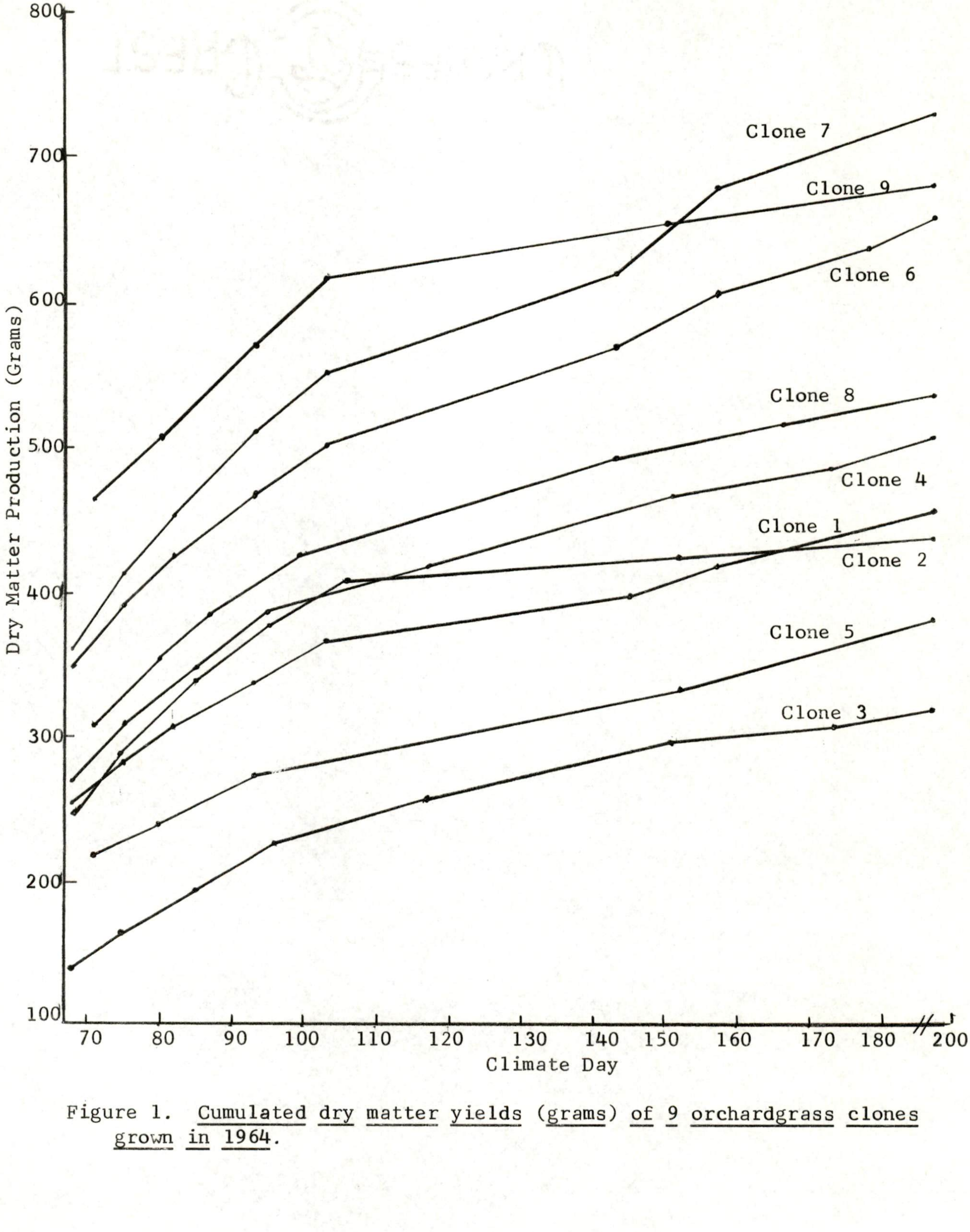

Figure 1. Cumulated dry matter yields (grams) of 9 orchardgrass clones grown in 1964.

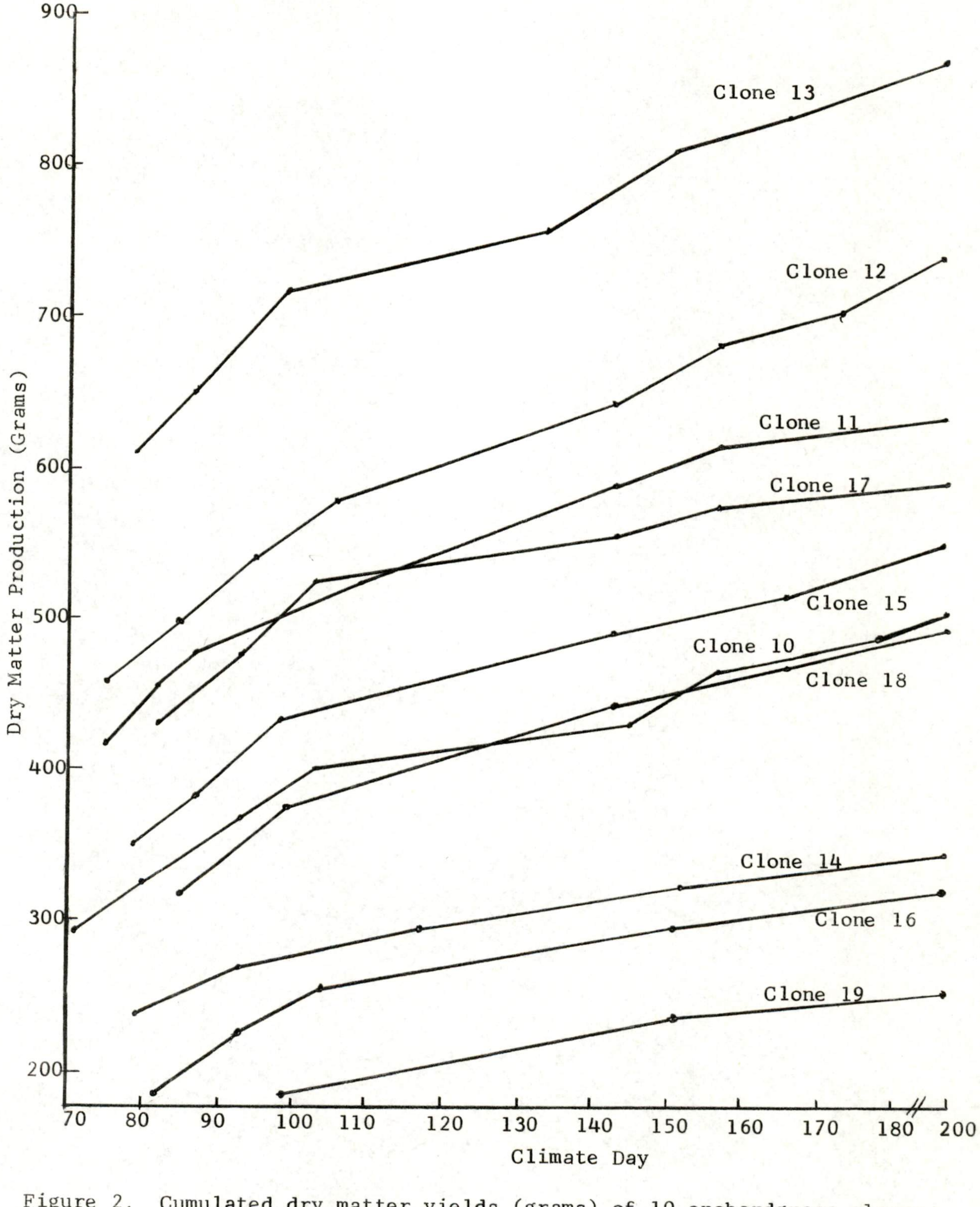

Figure 2. Cumulated dry matter yields (grams) of 10 orchardgrass clones grown in 1964.

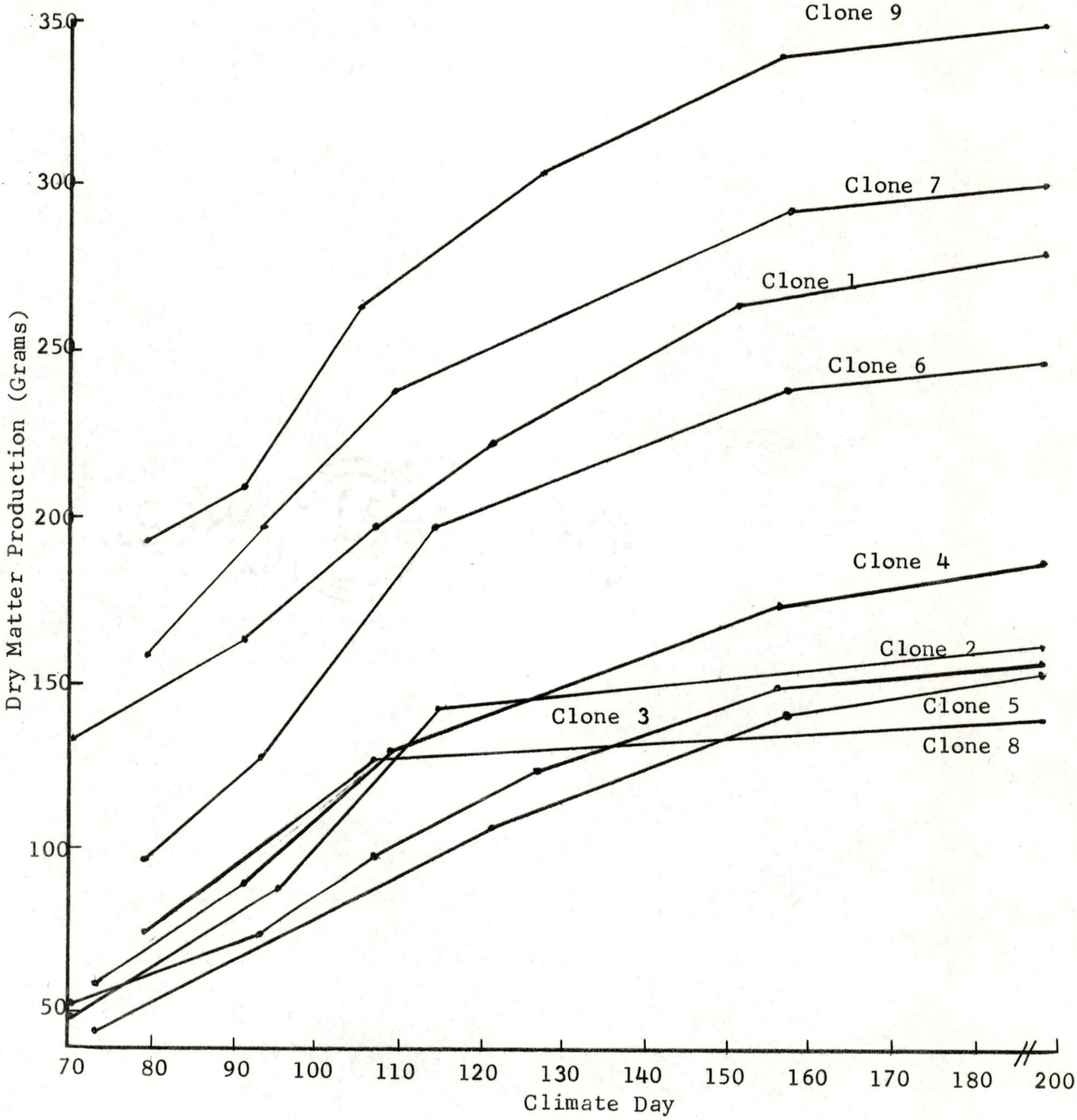

Figure 3. Cumulated dry matter yields (grams) of 9 orchardgrass clones grown in 1965.

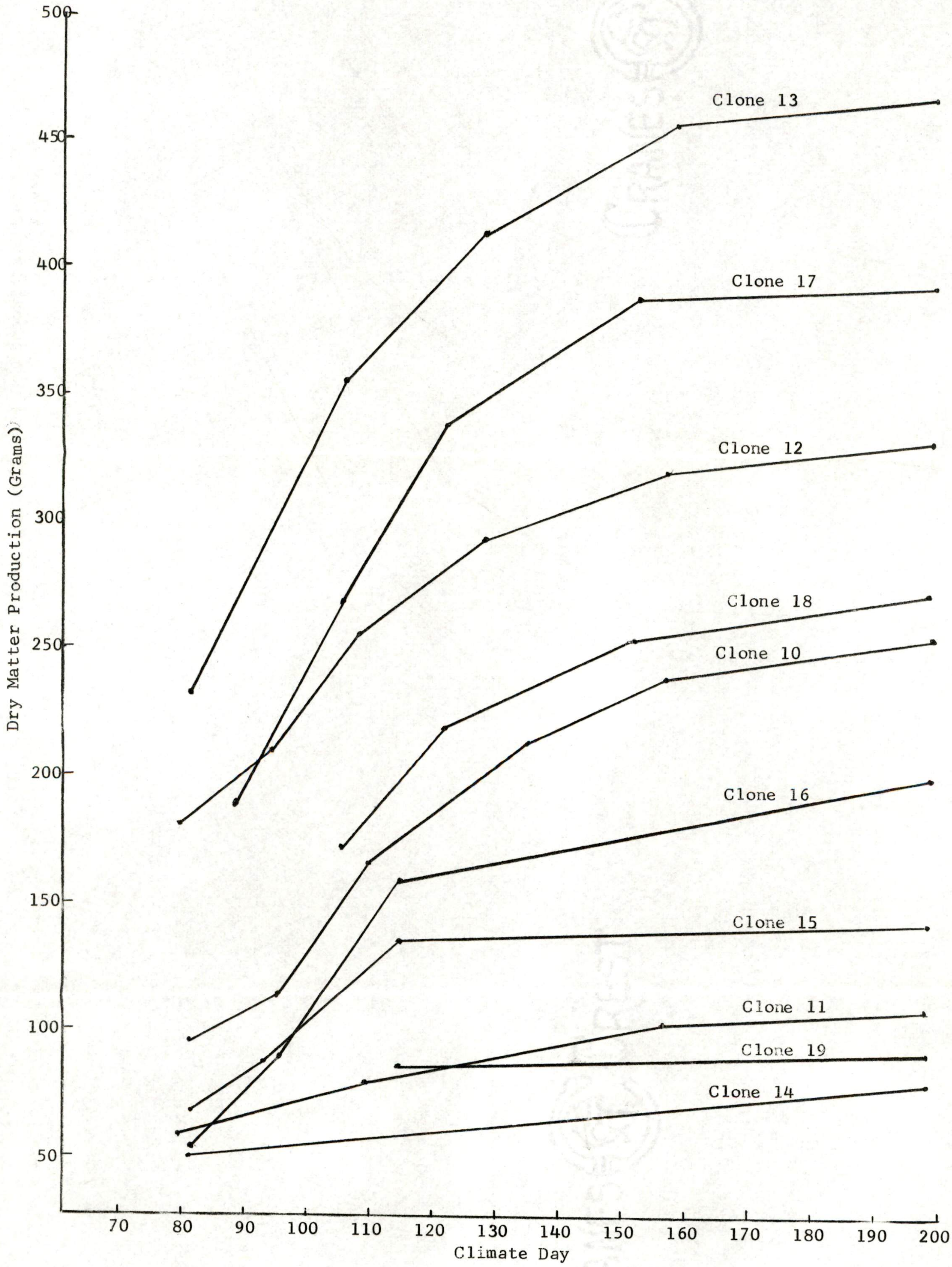

Figure 4. Cumulated dry matter yields (grams) of 10 orchardgrass clones grown in 1965.

maturity differences on dry matter percentages would give an indication of the effect of maturity on quality. Using only first harvest results (Table 15) correlation coefficients between maturity and dry matter percentage for all clones were: 1964, r = .445; 1965, r = -.115; for the two-year average, r = .166. These values were not significant at the .05 level of probability. Since the clones were all harvested at the anthesis stage, but on widely different dates, dry matter percentage of the first harvest would appear to be more related to physiological stage than to climate day.

Dry matter percentages for all harvests except the first and the last are given in Tables 16 and 17 for 1964 and 1965, respectively. The correlation coefficients between climate day and dry matter percentages for all clones were: 1964, r = .403; 1965, r = .763. These clones were all harvested when they reached 15 inches in height; therefore, these significant correlations imply that later in the season dry matter percentages are affected by climate day.

TABLE 15. Maturity and percentage dry matter of first harvest of 19 orchardgrass clones in 1964 and 1965.

	1964		1965		Average	
Clone	Maturity	Percent Dry Matter	Maturity	Percent Dry Matter	Maturity	Percent Dry Matter
1	68	22	70	31	69	26
2	68	22	70	32	69	27
3	68	22	70	31	69	26
4	68	24	73	33	70	28
5	71	27	73	37	72	32
6	68	23	79	33	74	28
7	68	21	79	32	74	26
8	71	23	79	32	75	28
9	71	22	79	32	75	27
10	71	26	81	34	75	30
11	75	22	79	31	76	26
12	75	22	79	30	76	26
13	79	24	81	29	80	26
14	79	29	81	33	80	31
15	79	25	81	32	80	28
16	82	25	81	32	82	28
17	82	25	88	27	85	26
18	85	25	105	31	95	28
19	99	25	114	33	106	29

TABLE 16. Date of harvest and dry matter percentage of aftermath harvests in 1964.*

Clone	Climate Day	Percent Dry Matter	Clone	Climate Day	Percent Dry Matter	Clone	Climate Day	Percent Dry Matter
1	75	23	16	93	28	1	145	29
2	75	23	2	95	26	17	145	28
6	75	22	4	95	26	10	145	32
7	75	38	12	95	26	16	151	32
3	75	23	3	96	28	9	151	35
4	75	21	15	99	26	4	151	28
10	80	23	18	99	24	13	151	25
9	80	25	11	99	24	19	151	34
8	80	20	8	99	25	3	151	27
5	80	29	13	99	24	5	152	41
1	82	22	10	103	20	2	152	34
6	82	21	17	103	23	14	152	30
7	82	20	7	103	23	1	157	26
11	82	21	1	103	24	6	157	27
4	85	22	6	103	24	7	157	27
2	85	23	9	103	26	11	157	24
12	85	24	2	106	28	12	157	26
3	85	24	16	106	40	17	157	29
15	87	25	12	106	41	10	157	30
8	87	22	3	117	38	15	166	34
13	87	24	14	117	44	18	166	35
11	87	20	4	117	42	13	166	30
14	93	32	13	134	31	8	166	45
1	93	27	15	143	34	12	173	23
6	93	27	12	143	28	3	173	27

TABLE 16 (continued)

Clone	Climate Day	Percent Dry Matter	Clone	Climate Day	Percent Dry Matter	Clone	Climate Day	Percent Dry Matter
5	93	34	18	143	31	4	173	24
7	93	24	11	143	33	1	178	27
17	93	17	7	143	31	6	178	27
10	93	28	8	143	30	10	178	28
9	93	28	6	143	33			

*First and last harvests were excluded.

TABLE 17. Date of harvest and dry matter percentage of aftermath harvests in 1965.*

Clone	Climate Day	Percent Dry Matter	Clone	Climate Day	Percent Dry Matter	Clone	Climate Day	Percent Dry Matter
1	91	32	8	107	20	9	127	30
4	91	32	1	107	25	12	127	30
8	91	30	3	107	21	10	134	31
9	91	36	10	109	24	18	151	41
13	91	27	7	109	23	17	151	39
6	93	30	4	109	23	1	151	39
3	93	23	11	109	24	12	156	40
12	93	28	2	114	23	11	156	44
7	93	29	6	114	29	10	156	38
15	93	31	15	114	32	9	156	46
2	95	31	16	114	29	3	156	45
10	95	32	18	121	29	4	156	46
16	95	31	17	121	31	7	157	42
17	105	24	5	121	39	5	157	42
13	105	24	1	121	27	6	157	46
12	107	21	13	127	29	13	157	37
9	107	24	3	127	34			

*First and last harvests were excluded.

CHAPTER V

DISCUSSION

Time of maturity was not a major factor in determining total yield or distribution of yield in this study. The highest yielding clones were found in the medium maturity group while high and low yielding clones were distributed throughout the maturity range. These results are in agreement with the findings of Davis (5) in which the outstanding varieties for total yield were in the medium maturity group. Murphy et al. (14) found that late maturing clones tended to produce a lower total yield than early maturing clones. In the present study some late clones were low in yield, but clone 17 which was quite late was a high yielding clone. Davis (5) noted that varieties in the medium maturity group gave better distribution of yield in Canada; however, in Tennessee production of all clones was low in middle and late summer and appeared to be independent of maturity.

Maturity of the earliest clones coincided with maturity of orchardgrass varieties adapted to this area. Clones such as 13 and 17 were high yielding but were approximately seven to ten days later than the earliest clones. This later maturity would coincide with the maturity of alfalfa and would permit better quality hay to be produced from orchardgrass-alfalfa mixtures. In view of the significant correlation between date of maturity of parents and their inbred progenies (10) and the fact that date of maturity is controlled by a relatively small number of genes (7), it should be possible to develop a high yielding orchardgrass variety that would mature about climate day 75 or about May 15.

Two-year average dry matter percentages for the 19 clones ranged from 26 to 31. With the reported relation (11) between dry matter percentage and digestible dry matter, there may be differences in digestibility among the clones. Differences in dry matter percentage of the first harvest were not related to date of maturity even though there was a 31-day range in 1964 and a 44-day range in 1965. Development of later maturing varieties should not result in lower quality.

After the first harvest dry matter percentage was related to climate day even though successive harvests were taken at a comparable stage of maturity. Although the relationship of maturity to dry matter percentage after the first harvest was not studied, it appears unlikely that they were related.

The early clones were harvested a greater number of times than were the later clones. Correlation coefficients between maturity and number of harvests for the clones were: 1964, $r = -.781$ and 1965 $r = -.494$. Even though 30 lbs. of nitrogen per acre were applied to an entry each time it was harvested, the early clones, as a group, did not yield more than other clones. Total yield and relative rank of the clones differed for the two years. The distribution of precipitation was different in 1964 and 1965 and likely caused some of the differences between years. The effect of soil moisture could be studied by incorporating an irrigation treatment into a study of this type.

With fall establishment of clones, first year stands appear to be more vigorous than older stands. By establishing tests containing the same clones on successive years the effects of increasing age of stands would not be confounded with year differences.

CHAPTER VI

SUMMARY

The relationship of maturity to total yield and distribution of yield in orchardgrass (<u>Dactylis glomerata</u> L.) was studied in replicated tests in 1964 and 1965 at Knoxville, Tennessee. Nineteen clones that were adapted to the southeast and had a wide range in maturity were used.

The first harvest was taken at the time of anthesis and subsequent harvest were taken when the plants of a clone reached about 15 inches in height. Each clone was harvested when it reached the designated stage of growth.

The range in maturity of the clones was 31 days in 1964 and 44 days in 1965. There were significant differences among clones for first harvest yields and total season yields for both years. These differences were not significantly correlated with date of maturity. The highest yielding clones matured about ten days later than the earliest ones. Aftermath yields were negatively correlated with date of maturity. Percentage of the total yield obtained in the first harvest was positively correlated to date of maturity. Production of all clones was low in middle and late summer.

Dry matter percentage of the first harvest were not significantly correlated with dates of maturity. For aftermath harvests, dry matter percentage increased as the climate day increased.

It appears feasible to develop high yielding, high quality orchardgrass varieties that mature approximately ten days later than presently adapted varieties. Such varieties would be expected to be more compatible with perennial legumes such as alfalfa.

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LITERATURE CITED

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