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SEASONAL PRODUCTIVITY OF SEEDED AND UNSEEDED ANNUAL RANGE

by

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INTRODUCTION

The benefits of seeding and fertilization on annual rangelands cannot be fully appreciated without seasonal measures of forage production that show the early forage production. The importance of early forage production on annual range has been stressed for many years (Bently and Talbot, 1951). However, most seeding and fertilization studies on California's annual rangelands have reported only total productivity at the end of the growing season.

A few reports of seasonal productivity have been presented. On nitrogen fertilized and unfertilized annual range on a Vallecitos clay loam in Santa Clara County, Martin and Berry (1954) clipped forage from February through May at monthly intervals. Application of N, P, and S produced forage 4 to 6 weeks earlier than the control and 2 to 3 weeks earlier than N and S only. Jones (1967) measured forage yield in December, March, April or May on a grazed and ungrazed Sutherlin loam at Hopland. The treatments consisted of subterranean clover seeded range and 4 levels of N on unseeded annual range with an uniform application of single superphosphate overall. Differences in December ranged from 1,000 lb/a for the control to 3,000 lb/a for the highest rate of nitrogen.

The objectives of this study were to determine seasonal yield response to fertilization of seeded and unseeded range and to confirm early forage production due to nitrogen fertilization and nitrogen fixation in the eastern foothills of the Sacramento Valley.

METHODS AND MATERIALS

Fertilizer Application

Adjacent clover seeded and unseeded pastures were selected for their similar site conditions on Auburn soil and on Corning soil. The seeded pasture contained rose and subterranean clovers (*Trifolium hirtum* and *T. subterraneum*) planted in the 1970's. No fertilizer had been applied until this experiment. The Auburn soil site is on a south facing slope 12 miles northeast of Marysville and 6 miles northwest of the Sierra Foothill Range Field Station in Yuba County. The Auburn soil is a loamy, mixed, thermic ruptic-lithic Xerochrepts (Inceptisols) and is dominated by a blue oak (*Quercus douglasii*) and interior live oak (*Q. wislizenii*) overstory and an annual range understory. The Corning soil is a fine, mixed thermic Typic Palexeralf (Alfisol) and is 9 miles south of Oroville in Butte County on an old valley terrace. The site is a relatively flat annual grassland.

On October 5, 1982, three treatments were applied to the seeded and unseeded pastures on the Auburn soil, 300 lb/a ammonium sulfate, 400 lb/a single superphosphate, and control. No fertilizer was applied in 1983, but forage was harvested to determine carryover effects. On October 14, 1983, the same treatments were applied to the Corning soil and forage was harvested for 2 growing seasons. The treatments were replicated eight times in plots 20 X 20 ft. on each pasture. Ammonium sulfate and single superphosphate were used because they are commonly recommended by the local farm advisors for this range soil.

Forage Sampling

The Annual Grassland Ecosystem Model (Pendleton, et al, 1983) simulates seasonal and yearly variation in forage production based on climate and soil data and suggests a strategy for sampling the seasonal productivity in an efficient manner. The date of the beginning of fall (occasionally winter) green-up is recorded as the beginning date for the growing season. The first harvest is taken shortly after the onset of cooling temperatures (mid November to early December) to estimate fall productivity. A second harvest is taken just before the onset of rapid spring growth (early February). A final harvest is taken at peak standing crop, commonly early May. Plotting these three yields produces a profile of seasonal productivity.

Before the first fall rains, 2 X 2 ft. cages were randomly placed in each plot. Forage harvests at the Auburn Series site were conducted according to the following schedule:

1. December 6, 1982, and December 5, 1983

2. February 1, 1983, and February 9, 1984

3. May 2, 1983, and May 9,1984

Forage at the Corning Series site was harvested according to the following schedule:

1. February 22, 1984, and March 1, 1985

2. May 8, 1984, and April 25, 1985

A December harvest date was difficult because the forage was less than 1 in. in height. We visually estimated the forage dry matter levels to be 200 to 300 lb/a at that time both years. The combined data were analyzed in a factorial design.

On each harvest date, clover composition was estimated in a one sq. ft. quadrat in the middle of each cage prior to clipping to ground level. Then each cage was moved to a new randomly selected location within the plot. After relocating the cage, we clipped another quadrat from outside of the cage to determine the current residue. The location for the residue clipping was selected for similarity in height and composition to that inside the newly-located cage (Brown, 1954). Clipped forage was oven-dried at 65 C for 48 hours and weighed. Protein was determined by the Kjeldahl method.

Weather data was obtained at the Sierra Foothill Range Field Station for the Auburn Series site. Valley weather data from Durham, California, 20 miles northwest of the Corning Series site, was obtained from the Integrated Pest Management Project's Impact data base.

RESULTS

Auburn Soil Series

Yields on the first harvest date (December) of each year were not significantly different for any treatment (Figures 1 and 2 and Table 1). Accumulated yields on the second harvest date were significantly different in 1983, but not in 1984. Accumulated yields on the third harvest date (peak standing crop) were significantly different each year.

Accumulated yields on February 1, 1983, for the seeded and unseeded sites fertilized with nitrogen and the seeded site fertilized with phosphorus were 1,751, 1,699, 1,942 lbs/a, respectively. These yields were significantly greater than those of other treatments on that date.

The application of single superphosphate to the clover seeding produced 7,220 lb/a at peak standing crop, a significant increase over all other treatments. Accumulated yield of 4,261 lb/a for the unfertilized clover seeding was significantly lower than the 5,690 lb/a on the unseeded pasture. When fertilized with ammonium sulfate, forage yield increased on the clover seeded and unseeded pastures. However, this increase was significant only on the clover seeded pasture.

The maximum accumulated yield at peak standing crop for the second growing season was 4,594 lbs/a on the nitrogen fertilized unseeded pasture and not significantly greater than the production by the unfertilized unseeded pasture. It was significantly greater than those of the other treatments. The yield 2,989 lbs/a on the clover seeded pasture fertilized with nitrogen was significantly lower than the 3,997 lbs/a produced on the unseeded unfertilized pasture. The second year yields of 3,641 lbs/a and 3,433 lbs/a produced by phosphorus fertilization of seeded or unseeded pastures, respectively, were not significantly different from those of the seeded and unseeded pastures that were not fertilized.

Table 1 shows the percentage of clover for each treatment. As the growing season advanced, the clover percentage increased significantly. Application of ammonium sulfate decreased the clover percentage from 37 to 15% in the fall of 1982. Phosphorus significantly increased the clover of the seeded pasture from 45 to 68% during the winter season. When averaged over all seasons, clover composition was unaffected by fertilizer treatments.

The decrease of clover from 67 to 48% was significant from the first year to the second year on the clover seeded pasture. The phosphorus fertilized, seeded pasture had a significant decrease of 32% clover from the first to the second year. On the unseeded annual grassland, the clover percentage was quite low but increased during the second growing season.

Protein levels of all treatments decreased as the forage matured (Table 1). These decreases were significant between the winter and spring seasons when mean protein content decreased from 19 to 10% in the first year and from 13 to 5% in the second year. Nitrogen fertilization significantly increased the protein content of the forage in the unseeded pasture by 6% in fall and 3% in winter. During the winter season, the protein level of the nitrogen fertilized clover seeded pasture decreased. However, by May forage protein on the unfertilized clover seeding was similar to that of nitrogen treatments on the unseeded pasture. Phosphorus fertilization increased the protein in the clover seeded pasture.

None of the fertilizers affected the protein content on either type of pasture during the second growing season. Forage protein the second year was significantly lower than the first year.

Corning Soil Series

Pooling seeded and unseeded pasture means produced significant fertilizer and date responses. Fertilizer X Pasture X Year X Date interactions were not significantly different (Figures 3 and 4 and Table 2).

Yields of 2,909 lbs/a and 2,164 lbs/a on the second harvest dates were significantly higher than the yields of 639 and 1,150 lbs/a on the first harvest dates of 1983 and 1984. Yield responses to the fertilizer treatments on Februray 22, 1984, were not significantly different. On the second harvest date in 1984 the nitrogen treatment mean for yield of 3,420 lbs/a was significantly greater than the phosphorus treatment mean of 3,039 lbs/a. The control treatment mean of 2,268 lbs/a was significantly lower than the mean for the phosphorus treatment. The phosphorus treatment yield was significantly greater than the yield of the control or nitrogen treatment on the first harvest in 1985. On the second harvest date in 1985 the fertilizer treatment means were not significantly different.

Clover composition means, pooled for the two years, were not significantly different between dates or fertilizer treatments (Table 3). The seeded means of 65 and 45%, respectively, for winter and spring were significantly higher than the unseeded means of 4 and 5% for winter and spring, respectively.

Protein (%) for each fertilizer treatment decreased significantly from winter to spring when pooled means for both years were analyzed (Table 3). At the end of winter 15% protein for the unfertilized treatment was significantly lower than the two fertilizer treatments. At peak standing crop 10% protein for the phosphorus treatment was significantly higher than the other treatments and nitrogen at 9% was significantly greater than the control at 8%. When unseeded means were compared to seeded means, protein content of the seeded means was significantly greater on both dates.

Precipitation

Table 4 indicates that precipitation in 1982-83 was above average and adequately spread throughout the rainy season. Precipitation in 1983-84 and 1984-85 was bimodal in occurrence with a dry period occurring in January of both years.

DISCUSSION

After fertilization in October, 1982, a significant early response was measured on the Auburn Soil Series in early February. This difference would not have been detected if the only harvest date was at peak standing crop in April or May. There was no significant difference in early yield on the Corning Soil Series.

December harvests on the Auburn Soil, two months after fertilization application, did not show significant differences between treatments. Apparently, fertilizer action and plant growth are slow and require a longer response time during cold weather. Likewise, nitrogen fixation is slowed by cold temperatures.

Productivity in the 1982-83 growing season was high due to high precipitation that was adequately spread throughout the growing season. Productivity in 1983-84 and 1984-85 was probably influenced by the below average precipitation that occurred in January of both years. January precipitation at the U.C. Sierra Foothill Range Field Station for 1984 and 1985 was .42 and .69 inches, respectively, while the 23 year mean for January is 5.71 inches. Closer scrutiny of winter precipitation patterns show that only .42 inches of rain fell from January 1 to February 8, 1984, and less than one inch of precipitation fell from December 17, 1984, to February 6, 1985. Below normal January precipitation may have contributed to the poor winter fertilizer responses in 1984 and 1985.

Early forage production has long been an important justification for fertilizing annual rangeland. Range productivity during the cool winter season is a major factor in setting long-term and short-term stocking levels. The results of this study and those of Jones (1967) and Martin and Berry (1955) suggest that this early response is not available until February which is usually the month of transition from the winter season to rapid spring growth.

A simple budget analysis (Table 5) of our results suggests that positive returns to nitrogen or single superphosphate fertilization occur if dry matter is valued at $60.00 per ton. A residue of 700 (Auburn) or 500

(Corning) lbs per acre was included in the calculations, (Clawson, et al). However, budget analysis of dry matter harvested from small plots is not an accurate decision aiding technique for several reasons:

1. Actual forage utilization by livestock seldom equals dry matter produced or dry matter availiable after residue adjustment.

2. Value based on dry matter alone does not account for differences in quality.

3. Clipped forage from small plots frequently over estimates actual field level productivity due to edge effect.

4. The value of the dry matter is not set in a market populated by a large number of buyers and sellers.

Forage harvest studies do not account for animal response to the fertilized forage which is a function of forage production, forage quality and forage intake. The economic feasibility of range fertilization and seeding can only be determined from field scale grazing trials where stocking rate, animal performance, and animal producivitity per acre are determined. Therefore, the economics of fertilization and seeding should be based on trials such as those by Martin and Berry (1955), and Raguse, et al (1984). Raguse, et al (1984) reported a positive one year financial return to single superphosphate applications with or without nitrogen application to an established annual legume seeding.

The results for the Auburn site in spring 1984 and the Corning site in spring of 1985 may underestimate forage yield, clover composition, and protein content at peak standing crop. Although the grasses were intact on these sampling dates, the forbs, including subterranean clover, had begun to shatter. Sampling one week earlier would have avoided this source of error and would have placed the sampling date closer to the time of maximum forage accumulation (peak standing crop).

SUMMARY AND CONCLUSIONS

Forage increases due to fertilization were measurable in February in a year of extremely favorable weather.

The timing of early forage production from fertilization coincides with the onset of warming spring temperatures.

Protein percentage decreased as the plants matured.

Precipitation and temperature patterns have a large influence on the magnitude and timing of response to range fertilization.

The Auburn series is inherently more productive than the Corning series because of soil and climate differences.

Inadequate January precipitation in 1984 and 1985 probably reduced forage production and response to fertilizer treatment.

Budget analysis of dry matter forage production does not reflect real economic conditions and should not be used to analyze the economics of range improvement practices. Actual animal productivity per acre should be used to reflect the economics of range improvement.

Care should be taken to conduct peak standing crop harvests before fragile forage components such as annual legumes begin to shatter.

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Table 1. Seasonal Accumulated Yield, Clover Composition, and Protein Content for Fall, Winter, and Spring on Fertilized and Unfertilized, Clover Seeded and Unseeded Annual Range.

	Yield (D.M. lbs/acre)			Clover Composition (%)			Protein (%)		
	Fall	Winter	Spring	Fall	Winter	Spring	Fall	Winter	Spring
1982-83 Season									
Unfertilized									
Seeded	747	1075	4261	37	42	66	21	20	10
Unseeded	872	1137	5690	1	0	9	18	18	9
Mean	810	1106	4976	18	21	34	19	19	9
Nitrogen									
Seeded	1043	1751	6187	15	39	59	24	15	11
Unseeded	1064	1699	6042	0	0	6	24	21	10
Mean	1054	1725	6114	8	20	33	24	18	11
Phosphorus									
Seeded	1040	1942	7220	45	68	74	21	22	13
Unseeded	1055	1282	5188	0	0	6	21	16	10
Mean	1048	1613	6204	23	41	45	21	19	11
Seeded means	943	1589	5889	32	53	67	22	19	12
Unseeded means	997	1373	5639	1	0	7	21	19	9
Overall means	970	1481	5764	16	34	37	22	19	10
1983-84 Season									
Unfertilized									
Seeded	545	1179	3399	15	12	51	16	14	5
Unseeded	524	1509	3997	1	1	22	17	11	6
Mean	535	1344	3698	8	6	35	16	12	6
Nitrogen									
Seeded	666	1614	2989	21	38	54	15	15	5
Unseeded	607	1642	4594	0	2	11	14	12	5
Mean	637	1629	3792	11	20	28	15	13	5
Phosphorus									
Seeded	695	1400	3641	24	26	41	18	15	5
Unseeded	485	1654	3433	0	2	10	15	12	5
Mean	590	1527	3538	14	13	26	16	13	5
Seeded means	635	1397	3343	20	27	48	16	14	5
Unseeded means	539	1602	4008	0	2	14	15	12	5
Overall means	587	1500	3676	11	13	30	16	13	5
L.S.D. (0.05)		660			16			3	

Table 2. Seasonal Accumulated Yield for Winter and Spring of Two Growing Fertilized and Unfertilized, Clover Seeded and Unseeded Annual Range

	Accumulated Yield (%)	
	Winter	Spring
1983-84 Season		
Control		
Unseeded	7	25
Seeded	8	20
Nitrogen		
Unseeded	7	41
Seeded	4	28
Phosphorus		
Unseeded	5	32
Seeded	7	29
1984-85 Season		
Control		
Unseeded	10	23
Seeded	10	19
Nitrogen		
Unseeded	10	23
Seeded	12	20
Phosphorus		
Unseeded	11	25
Seeded	16	20
1983-84 Fertilizer means		
Unfertilized	7	23
Nitrogen	6	34
Phosphorus	6	30
1984-85 Fertilizer means		
Unfertilized	10	21
Nitrogen	11	22
Phosphorus	13	23
L.S.D. (5%)	3	
1983-84 means	6	29
1984-85 means	12	22
L.S.D. (.05)	1	

Table 3. Clover Composition, and Protein Content for Winter and Spring of Two Growing Seasons for Fertilized Unfertilized, Clover Seeded and Unseeded Range

	Clover Composition (%)		Protein (%)	
	Winter	Spring	Winter	Spring
1983-84				
Control				
Unseeded	4	2	12	8
Seeded	57	46	14	8
Nitrogen				
Unseeded	2	0	14	8
Seeded	48	40	17	10
Phosphorus				
Unseeded	12	25	13	9
Seeded	76	53	17	10
1984-85				
Control				
Unseeded	0	1	18	8
Seeded	61	31	17	8
Nitrogen				
Unseeded	1	0	21	8
Seeded	71	51	25	10
Phosphorus				
Unseeded	3	5	19	8
Seeded	74	51	26	11
2 Year Fertilizer Means				
Unfertilized	31	20	15	8
Nitrogen	30	23	19	9
Phosphorus	41	34	19	10
L.S.D. (5%) Fert. X Date	n.s.			1
2 Year Seeded Means				
Unseeded means	4	5	16	8
Seeded means	65	45	19	10
L.S.D. (5%) Seeded X Date		5		1
2 Year Means	34	25	18	9
L.S.D. (5%) Dates		4		0

Table 4. Monthly precipitation during the range growing season at the U.C. Sierra Foothill Range Field Station and in Durham, California.

Years	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
						U.C. Sierra Foothill Range Field Station							
82-83	1.23	3.06	5.89	4.46	7.62	7.66	8.41	4.44	.36	.36	.00	.34	43.83
83-84	.69	1.40	8.58	10.87	.42	3.30	2.19	1.01	.25	.21	.00	.35	29.27
23 yr. Mean	.36	2.17	4.73	4.61	5.71	3.89	3.70	2.23	.41	.32	.11	.13	28.44
						Durham, California							
83-84	1.10	.83	6.55	11.47	.44	1.79	1.85	1.06	.12	.04	.00	.75	26.00
84-85	.16	2.01	6.70	1.85	.55	1.02	3.00	.24	2.64	.00	.52	.24	18.93
23 yr. Mean	.43	1.61	3.55	4.18	5.75	3.94	3.07	2.04	.72	.42	.05	.17	25.93

Table 5. Budget analysis of first year and two year fertilizer costs and forage yields.

Auburn Soil Series

	First Yr.			Two Years		
	Unfertilized	Ammonium Sulfate	Single Superphosphate	Unfertilized	Ammonium Sulfate	Single Superphosphate
Fertilizer Cost ($)	0	40	44	0	40	44
Forage Yield (D.M. lbs/acre)	4976	6114	6204	4337	4953.5	4871
Forage from fertilization (lbs/acre)		1833	1928		1316.5	1234
Gross Return ($)		55.14	57.84		39.495	37.02
Net Return ($) to fertilizer		15.14	13.84	0	-.505	-6.98

Corning Soil Series

	First Yr.			Two Years		
	Unfertilized	Ammonium Sulfate	Single Superphosphate	Unfertilized	Ammonium Sulfate	Single Superphosphate
Fertilizer Cost ($)	0	40	44	0	40	44
Forage Yield (D.M. lbs/acre)	2268	3420	3039	2163	2799	2647
Available Forage (D.M. lbs/acre)		1852	1471		1336	1184
Gross Return ($)		55.56	44.13		40.08	35.52
Net Return ($) to fertilizer	0	15.56	.13	0	.08	-8.48

Note: 700 lbs/acre of forage was subtracted from all treatments to simulate unused residue.

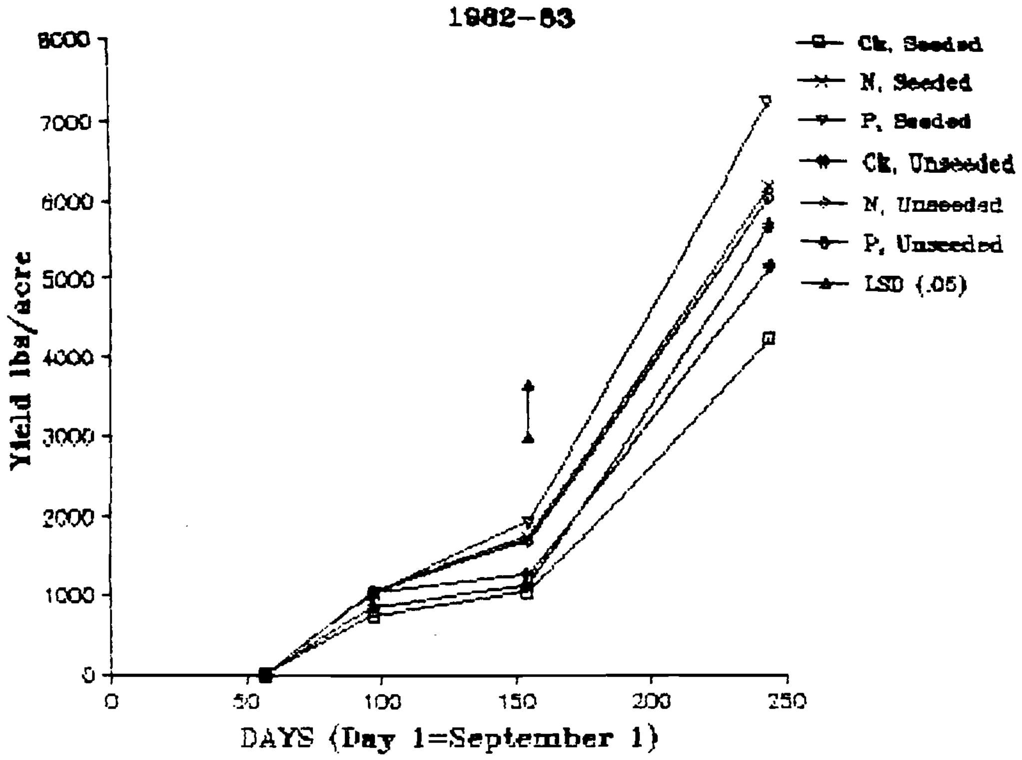

Figure 1. Seasonal dry matter yield (lbs./acre) for the Auburn Series site in 1982-83.

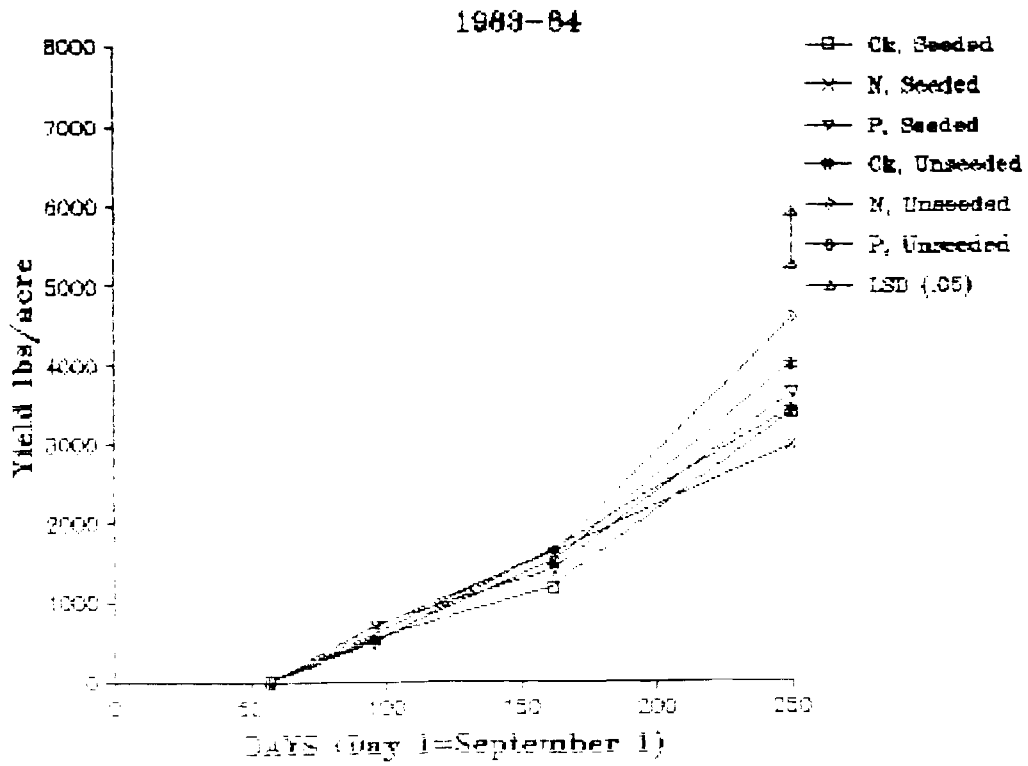

Figure 2. Seasonal dry matter yield (lbs./acre) for the Auburn Series site in 1983-84.

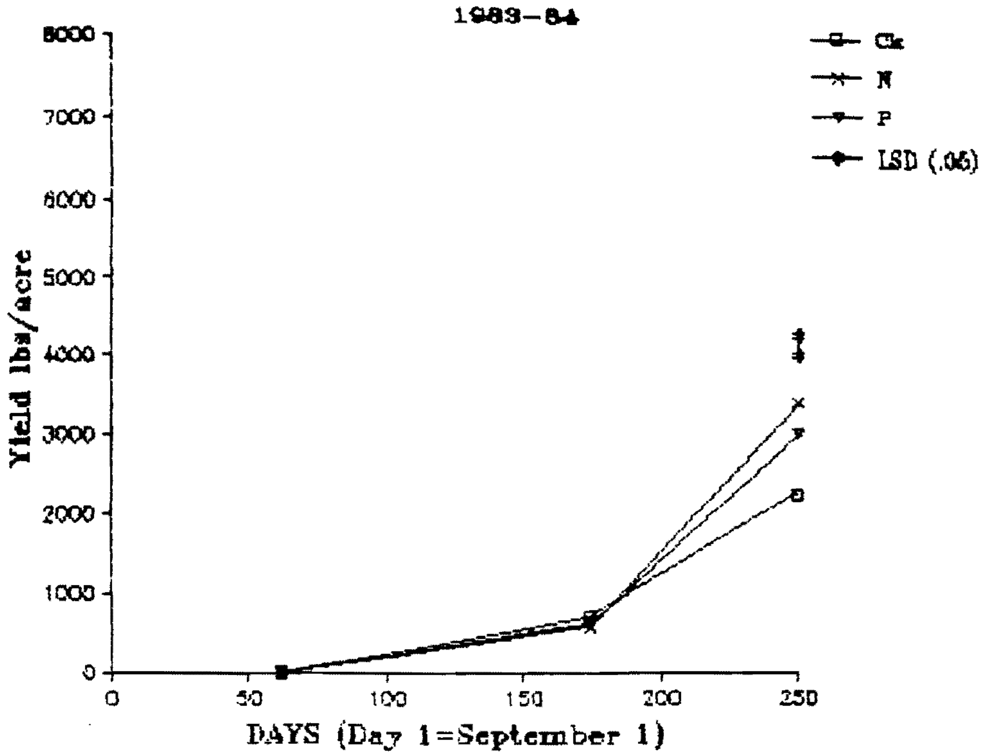

Figure 3. Seasonal dry matter yield (lbs./acre) for the Corning Series site in 1983-1984.

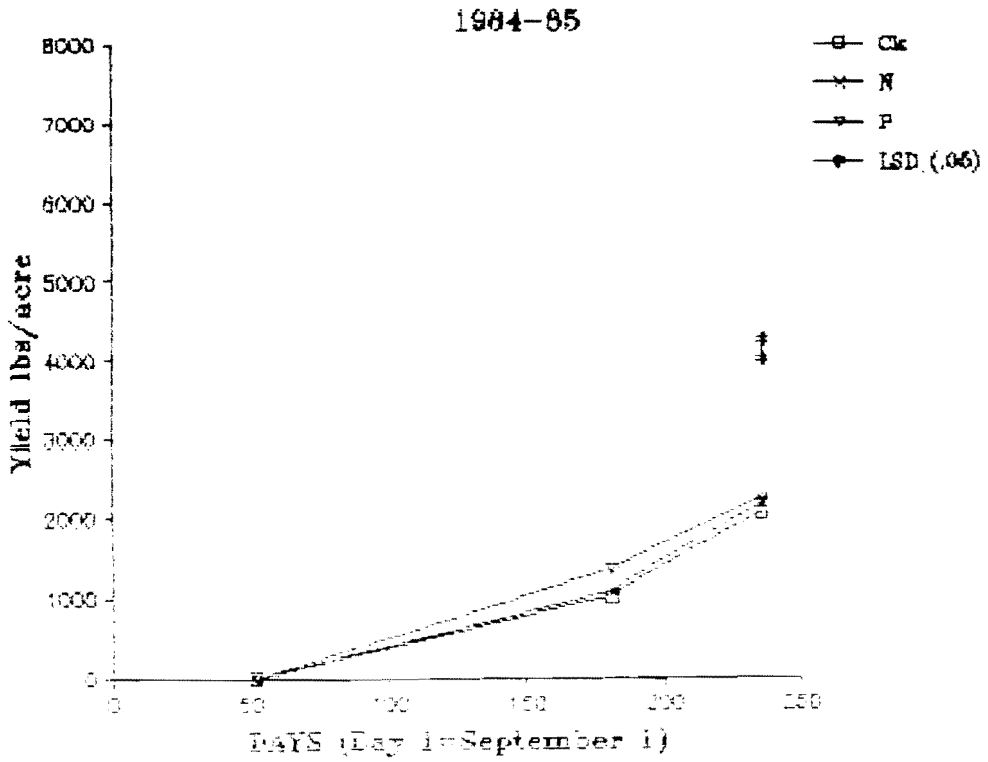

Figure 4. Seasonal dry matter yield (lbs./acre) for the Corning Series site in 1984-85.