Management Alternatives for Native Meadowlands

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MANAGEMENT ALTERNATIVES FOR NATIVE MEADOWLANDS

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FOREWORD

The primary objective of this report is to summarize Squaw Butte Agricultural Experiment Station meadow research and published reports of relevant research from other locations. The latter include research results from the western United States, Canada, eastern Europe, and USSR.

Acknowledgment is given to colleagues and predecessors at the Squaw Butte Agricultural Experiment Station for their work in reporting much of the data from which this publication was drawn. Special recognition is given to C. S. Cooper and C. B. Rumburg for their work on fertilization and plant management and to R. J. Raleigh, J. D. Wallace, F. Hubbert, and R. R. Wheeler for their work on testing quality of meadow forage as it relates to livestock performance. Most of these studies were done under superivision of W. A. Sawyer and R. J. Raleigh, station superintendents, in close cooperation with the Agricultural Research Service, U. S. Department of Agriculture, now Agricultural Research, Science and Education Administration, USDA.

INTRODUCTION

The perishable nature of most agricultural products requires that they be disposed of annually. Consequently, the selling price is fixed by supply and demand with little regard to the cost of producing and getting the commodity to market. When the supply of beef, for instance, is high and the selling price is relatively low, it becomes necessary for the producer to reduce his operating costs accordingly.

The successful rancher who relies on meadowland for winter feed and supplemental grazing may be flexible enough in his management to maintain a steady number of marketable animals and can adjust his operation to the rise and fall of market prices. He has several alternatives in managing his forage resources, and economics at the time will determine how he best can take advantage of those management alternatives.

NATIVE MEADOWS

In the 11 western states, 4,042,000 acres have been classified as mountain meadows. Of this area, 1,985,000 acres are owned privately (Forest-Range Task Force, 1972). A recent survey (Oregon Department of Environmental Quality, 1976) indicates that 227,000 acres were irrigated in the Malheur-Harney Basin in 1967 of which 211,000 were by stream flow, 7,500 by reservoir storage, and 8,600 by ground water. Most of the 211,000 acres irrigated by stream flow was by wild flooding to produce native hay.

The average production of native meadows in eastern Oregon is about 3/4 to 1 ton/acre (Cooper, 1955; Powers and Johnston, 1920; Rumburg, 1961). Reports from other western states and from Czechoslovakia, Poland, and the USSR also suggest similar low yields from native, untreated meadows (Sanderson, 1967; Kolomentsev and Kazymov, 1968; Larin, 1973; Ryswyk and Bawtree, 1971; Yurkevich and Burtys, 1969; Lewis, 1957; Willhite et al., 1957).

Much of the meadow hay in the Malheur-Harney Basin is produced using a primitive system of wild flooding. Seasonally, the water is diverted from streams with dams and spread over the land by means of ditches and dikes. The meadows remain flooded until the flood water is exhausted.

Research has shown possible alternatives that could be used to improve the quality and quantity of native forage from the seasonally flooded meadows. Included are 1) controlled irrigation and drainage, 2) approximate harvesting date and methods, and 3) adequate fertilization.

Water control

Typically, the plants native to the wild flood meadows are hydrophytes, principally rushes and sedges, with some grasses. The water-depth and duration of flooding determine the productivity of the meadow and which species will dominate (Mornsjo, 1969; Walker and Wehrhahn, 1971). Results of work from southeastern Oregon (Rumburg and Sawyer, 1965) and from Wyoming (Lewis, 1957, 1960) show that rushes increase with length and depth of flooding while the density of sedge and grasses decreases. When rushes and sedges are the major species, hay yields increase with length and depth of flooding as long as the depth is less than 5 inches. At flooding depths of more than 5 inches for longer than 50 days, production decreases, Native legumes usually are a minor part of the meadow vegetation unless managed to replenish the seed and phosphorus supplies.

In Czechoslovakia (Balatova-Tulackova, 1970), studies indicated that the botanical composition of the meadow is related to the level of the water table at the beginning of the growing season and not to the average water table level. This observation, however, is contrary to the conclusion of Prochal (1970) in Poland, who concluded that the plant composition and forage value of wet meadows depend on the average ground water level during the growing season. In another study in Poland (Pronczuk, 1970), which included 204 plant species, it was determined that the most critical period of flooding on the botanical composition of a meadow was June 20 to July 10.

Studies in Nebraska (Moore and Rhoades, 1966) showed that soil moisture and soil temperature are strongly affected by water table depth. During most of the growing season, the soil temperature at the 4-inch depth was 60 to 75°F and aeration was good, with an oxygen content of 15 percent to 3 feet deep. Nevertheless, roots were concentrated near the surface with one-half to two-thirds of the roots in the surface 2 inches.

Although protein concentration of rushes and sedges is about equal to that of grasses, but not as high as that of legumes (Figure 1). Forage yield of rushes and sedges are lower. Therefore, management systems which increase rushes and sedges and reduce the higher-producing grasses and legumes will reduce the overall productivity of the meadow. Because of the low production of rushes and sedges, Lewis (1957) in Wyoming and Ryswyk and Bawtree (1971) in Victoria, Canada, concluded that the control of water level is the most important factor in the management and improvement of wet meadows.

To improve these lands it would be necessary to build drainage ditches and levees and obtain better storage and control of the irrigation water. Under the present system of wild flooding, however, water control is difficult because of the dependency of one neighbor on another for the distribution of water and because of the resultant high water table. Unless distribution and drainage can be controlled, the meadows should be flooded as early in the spring as possible and at a shallow depth, especially in areas where spring frosts damage early growth.

Where possible, intermittent flooding at weekly- to two-week intervals will help change the vegetation composition toward the grass species. This might be accomplished by a series of dikes and ditches to move the water across the field. In Wyoming, improved intermittent irrigation increased yields from 3/4 to 2 1/2 tons/acre and crude protein yields were tripled (Lewis, 1957, 1960). With controlled water management, vegetation changes can be made in 2 to 3 years. Little changes will occur in the first year of treatment,

Besides the improvement in quality and quantity of hay produced by controlled irrigation, more efficient use can be made of the available water. In Wyoming and Colorado, Lewis (1960) and Willhite et al. (1957) determined that approximately 136 acre-inches of water was required for each ton of wild hay grown where continuous flooding was practiced (16,000 pounds of water/pound of hay and 208,000 pounds of water/pound of beef). By intermittent flooding at weekly-to two-week intervals, a practice which increased the amount of grass, only 12-acre inches of water was required to produce a ton of hay. The water requirement was further reduced to 7 acre-inches of water per ton of hay when the native rush-sedge meadow was converted to improved grass-legume mixtures. In Nevada (Dylla and Muckel, 1964), the average daily consumptive use of water by native meadow grass was 0.15 acre-inches. This amounted to about 10 acre-inches of water per ton of hay (1,080 pounds of water/pound of hay and 13,000 pounds of water/pound of beef). Under an improved management system, the unused water could be made available to irrigate previously dry land.

Hay harvest

Many studies in Oregon, Wyoming, and Colorado have shown that the crude protein concentration in forages declines steadily as plants mature, and the hay produced becomes coarser and lower in feeding value (Raleigh et al., 1964; Rumburg et al., 1964; Willhite et al., 1957; Stewart and

Clark, 1944; Miller and Amemiya, 1954; Seamands, 1966; McLean et al., 1963).

To obtain maximum yield of high-protein hay, grass forage should be cut at the flowering to soft dough stage of growth. In the Malheur-Harney Basin, that stage is reached about July 1 to 15 (Figure 2) (Cooper, 1956a; Rumburg et al., 1964). Protein concentration will decline after the soft dough stage at the rate of about 0.08 percent per day until a low level of 3 to 4 percent crude protein is reached.

In Colorado (Willhite et al., 1955), hay cut August 1 was superior in feeding value to hay cut in early September. One pound of 43 percent crude protein cake supplement per animal per day was required to raise the feeding value of the late cut hay to equal the early cut hay. The researchers reported a direct relationship between the crude protein concentration in the daily ration and the rate of animal gain. This, however, is only true up to the point of the animal's requirement for a given energy level, assuming vitamin and mineral requirements are met.

The time and height of cutting meadows affect the quality and quantity of hay. With the one-cut system commonly practiced, the maximum dry matter of wild hay is obtained by letting the plant approach maturity. McLean et al. (1963) found that in sub-alpine areas of Canada, 90 percent of the season's growth took place before the end of July; in eastern Oregon, however, it was found that the maximum season's growth occurred about the first of July (Cooper, 1956b). At both locations, however, additional regrowth can take place if temperature and soil moisture are conducive to plant growth, provided the plants have not become dormant during a dry period. If cut late, rushes and sedges do not recover well (Rumburg, 1963). Keefe (1972) and Bernard (1973) have reported decreased production with increased altitude and latitude, and Gorham (1975) showed a positive correlation between the temperature of the warmest month and production of sedge meadows.

Not only does the protein concentration decrease as the season progresses, but the digestibility of the forage also declines (Table 1). In feeding trials in Oregon (Raleigh et al., 1964) it was observed that the digestibility of protein, cellulose, and gross energy declined as meadow plants became more mature. It was further noted that the differences between years were often greater than between harvest dates. These variations were undoubtedly caused by environmental influences, flooding, weather, etc. which affected changes in species composition and subsequently the forage quality. Streeter et al. (1974) reported that the cell wall constituents in the diet of grazing cows increased from 47.2 to 62.1 percent from mid-June to mid-October; at the same time, the digestibility of the cell wall constituents decreased from 72.8 to 52.3 percent, the nitrogen concentration in the diet decreased from 3.1 to 1.2 percent, and the dry matter consumed decreased from 31.2 to 22.7 pounds/head/day.

The height of cutting should be as low as possible when harvesting meadow hay, and the forward rate of travel of the mower or swather should be slow enough to prevent sliding over the hay. Because sedges and bluegrass, in particular, have basal growth characteristics, most of the herbage produced is in the lower 6 inches. Cooper (1956b) reported that raising the cutting bar from 2 to 4 inches resulted in a loss of 40 percent in hay yields (Table 2). The low setting of the cutting bar would not be so important with tall-growing grasses such as beardless wildrye and reed canarygrass which produce most of their leafy growth from the stalk. The height of cutting had no effect on the yield in subsequent years,nor did it affect species composition. In Wyoming, Pond (1961) observed that clipping to 1-inch stubble at the end of the season had no effect on species composition of plant density. However, frequent clippings were shown by Pond (1961) and by McLean et al. (1963) to retard growth and reduce yield in the next growing season.

As might be expected, Cooper (1956b) found that raising the cutting height increased the protein concentration in the harvested forage (Table 2). This was because the upper leafy portion of the plant is higher in protein than the lower stems.

Where water conditions permit, cutting twice during the growing season increases the quality of the total forage but may decrease the total dry matter yield. In Colorado, it was reported by Willhite et al. (1955) that a single cutting of meadow hay yielded 1.8 ton/acre with 7.9 percent crude protein, whereas two cuttings during the season yielded only 1.4 ton/acre with 10.5 to 11.6 percent protein. Consequently, the two-cutting system yielded less dry matter but more protein per acre. Hunter (1959), however, found that the two-cutting system increased protein yield and also increased the dry matter yield (Table 3). In other studies, Miller et al. (1955) reported that highest protein yields were obtained from high altitude meadows in Colorado when the first harvest was made near the end of June (Figure 3). Wolf (1971) reported that dry matter production was decreased by increasing the number of harvests, but the concentrations of crude protein, potassium, phosphorus, magnesium, and sodium were increased and crude fiber was decreased. The total amount of feed produced was about the same regardless of whether it was spring grazed and hayed, cut for hay alone, or cut for hay early, then fall grazed (Miller and Amemiya, 1954). Also, work in Wyoming (Stewart and Clark, 1944) suggested that prolonged spring grazing followed by haying not only increased the total forage yield, but also increased the protein concentration in the hay and the total protein yield. The assurance of producing satisfactory hay yields following comparatively late spring grazing, however, depends on the supply of irrigation water available late in the growing season.

In feeding trials in Nevada (Shipley and Headley ,1948), yearling steers fed early-cut hay (July 10) consumed approximately a third more hay than those fed late-cut hay (September 10). Steers on early-cut hay gained 1.5 pounds/head/day while those on late-cut hay lost weight (-0.02 pounds/head/day). It was concluded that the difference in gain was attributable to the difference in feeding quality more than it was to the difference in intake. Further tests of these animals showed that steers which had lost weight from late-cut hay gained more rapidly when they were later fed alfalfa hay, meadow hay, or pasture than those which had received early-cut hay. They made up in part the difference in weight. However, when sold, those animals which had been fed early-cut hay during the preceeding winter were more profitable than those fed late-cut hay. Studies in Colorado and Oregon have shown similar results and confirmed the fact that early-cut hay has higher nutritive value, greater digestibility, and produced greater gains than hay cut late in the season (Hunter, 1959; Rumburg et al., 1964; Wallace et al., 1961; Willhite et al., 1957).

Fertilization

The response of meadow plants to fertilization depends on the species and the available soil moisture. Grasses respond more to nitrogen than do sedges, legumes, or rushes (Daigger and Burzlaff, 1972; Cooper and Sawyer, 1955; Lyubchenko, 1966; Leamer, 1963; Mazur and Mazur, 1972). Legumes respond to phosphorus (Leamer, 1963; Mika, 1969; Skripko, 1972). Sedges and rushes respond very little to added fertilizers (Cooper, 1956a; Lewis, 1957; Rumburg, 1961). With added nitrogen, the grasses increase while sedges, rushes, and legumes decline (Figure 4). Changes in species composition are fairly rapid but are more pronounced after the first year. To maintain a change in composition, fertilizer treatments must be applied annually.

In New Mexico, the grasses responded linearly to fertilizer up to 240 pounds/acre of nitrogen with increased hay yield and protein concentration (Leamer, 1963). The most economical rates in eastern Oregon appear to be about 80 to 100 pounds/acre (Table 4). At these rates, 1 pound of nitrogen will increase forage yields about 20 to 25 pounds and 80 pounds/acre would increase yields about 3/4 to 1 ton/acre (Nelson and Castle, 1958; Rumburg, 1961). About 20 pounds/acre of P is adequate to maintain an established stand of clover at optimum production (Cooper, 1957).

In Wyoming, Lewis (1960) reported increases of 2 to 4 tons/acre from fertilizer, but this was with improved varieties and with good water management. The average yields of hay from 0, 80, and 160 pounds nitrogen per acre applied annually were 1.8, 3.6, and 4.4 tons/acre, respectively, and the respective average yields of crude protein were 226, 588, and 1,000 pounds/acre. Some continuously flooded sedge-rush meadows, although fertilized with 160 pounds nitrogen per acre, yielded less than 1 ton/acre (Lewis, 1957).

In Poland, Mazur and Mazur (1972) found that application of nitrogen increased grasses 82 to 98 percent and decreased forbs and weeds. Likewise, phosphorus increased legumes from 4 percent without phosphorus to 30 percent with phosphorus. Hay yields increased from 0.72 ton/acre without fertilizer to 3.2 ton/acre with fertilizer. When fertilized with nitrogen, phosphorus, and potassium at rates equivalent to 180-90-70 pounds/acre, the content of manganese, copper, cobalt, zinc, molybdenum, and boron also was increased. In Russia (Panferov, 1971), similar rates of fertilizer increased yields from 1.22 to

3.04 tons/acre. Increasing nitrogen to 300 pounds/acre increased hay yields to 4.01 tons/acre. Also in Russia, Skripko (1972) found that phosphorus-potassium fertilizer increased the proportion of legumes from 13 percent to 39 percent. The addition of nitrogen to the fertilizer decreased the legume content to less than 1 percent and decreased the proportion of other herbs by about 50 percent while grasses increased 35 percent. Yurkevich and Burtys (1969), in Russia, found that potassium alone increased the legume content more than any other fertilizer.

Contrary to most studies, Russell et al. (1965) found that on meadows in the sandhills of Nebraska, nitrogen alone did not increase forage yields. Combinations of nitrogen and phosphorus increased yields, but it appeared that yield response and chemical composition of the forage were the result of changes in botanical composition. Phosphorus increased the legume content of the forage. They also determined with P^{32} that legumes used greater amounts of phosphorus than did the grasses. The application of nitrogen, however, appeared to increase the utilization of phosphorus by the grasses.

Increased yields with phosphorus on Oregon meadows were believed to be almost entirely caused by stimulation of clover, increasing yields from 1.2 ton/acre to 1.6 ton/acre (Cooper, 1957). Phosphorus increased the crude protein concentration of meadow forage indirectly by increasing the amount of clover, and the protein concentration was in proportion to the clover composition by weight. The concentration of crude protein in the clover averaged 12.6 percent as compared to 8.2 percent for the associated grass and grass-like species. The protein concentration in the clover, however, declined as the plants matured.

Apparently, nitrogen is rapidly accumulated in the herbage even when applied near plant maturity (Figure 5) (Rumburg, 1972). After the initial application, the concentration of nitrogen peaked 1 to 2 weeks later. It then declined to a level of about 1.2 percent at the end of August. The effect of nitrogen fertilizer is not long lasting on flood meadows, as indicated by the lack of regrowth response to fertilization. In Colorado (Miller and Amemiya, 1954), no response was obtained in hay yields, crude protein concentration, or yield of crude protein in regrowth even when an initial harvest was removed less than 2 weeks after 80 pounds nitrogen per acre had been applied. The concentration of crude protein in fertilized forage, therefore, was dependent on the length of time from application to harvest. After the initial uptake of nitrogen, the decline in crude protein concentration appears to be a dilution effect as maturity approaches (Rumburg et al., 1964).

Occasionally, the crude protein concentration in mature meadow hay may decline after fertilization with nitrogen (Slinkard, 1964). This is especially true if the legume component is significant at time of fertilization. The reduced concentration is indirectly caused by a reduction in the legume component after fertilization with nitrogen (Cooper, 1956a; Rumburg, 1961).

The source of fertilizer nitrogen appears to have no significant effect on yield or crude protein concentration in meadow hay. Neither does the time of application (Leamer, 1963; Rumburg, 1961 and 1969). In northern California, however, fertilizer applied in the spring appeared to give better results than did fall application (Bedell, 1962). In Poland, Mazur and Mazur (1975) determined that responses to ammonium nitrate and urea were similar when applied at rates of 90 pounds nitrogen per acre, but at 180 pounds nitrogen per acre, ammonium nitrate was more effective and produced hay with higher concentrations of nitrogen, magnesium, copper, manganese, and zinc.

As a management practice, it may be advisable to delay fertilizing meadows until the probability of receiving adequate irrigation water is determined. In dry years, fertilizing with nitrogen when soil moisture is limited might reduce total forage yield and may cause nitrate to accumulate in plant tissues to a level which is potentially toxic to livestock (Gomm, 1978). When an ample supply of water is available; however, fertilizer increases the water use efficiency (Figure 6).

Although some studies in Colorado have shown that cattle used unfertilized forage more efficiently than fertilized forage, it was concluded that the average daily gain (ADG) of calves fed fertilized forage was as high as that for those fed hay from unfertilized meadows (Willhite et al., 1957).

In Oregon, Wallace et al. (1961), using in vitro digestion trials, found nitrogen fertilization rates up to 240 pounds/acre increased protein and decreased cellulose concentration in native hay, but at 320 pounds/acre the cellulose concentration was similar to that of unfertilized hay. They also found that after May 18, the digestibility of cellulose decreased and it was lower in hay grown with fertilizer at rates above 160 pounds/acre than it was in hay fertilized at lesser rates. Part of this change may have been caused by change in species composition.

Hay from phosphorus fertilized meadows in Oregon (Hubbert et al., 1958) showed increased crude protein and phosphorus concentrations. Feeding trials also showed increased ADG from the phosphorus-fertilized forage as compared to hay from unfertilized meadows. The difference was attributed to the increase in clover from the phosphorus treatment.

Grazing

The carrying capacity of flood meadows varies with location, altitude, species, and growing conditions. Environmental conditions favoring high forage production also are those which promote the growth of high producing grasses and legumes. Consequently, the grazing capacity is high. A survey of 206 mountain meadows on the eastern slopes of the Sierra Nevada Mountains showed that the carrying capacity of the meadows was strongly influenced by range condition and by altitude (Crane, 1950). Meadows in excellent range condition had a carrying capacity of 3.4 animal unit months (AUM) per acre at 5,500 feet and only 1.7 AUM/acre at 9000 feet. Similarly, those meadows in good condition had a carrying capacity of 2.2 AUM/acre at the lower elevation and 1.1 AUM/acre at 9,000 feet. Likewise, the grazing capacity of poor meadows was reduced to 0.8 and 0.4 AUM/acre.

The grazing capacity on an Oregon meadow was shown to be 1 yearling/acre for 5 months (3 AUM/acre). On this basis, 1 acre of meadow produced 244 pounds of yearling beef. If cut for hay, the meadow would have yielded 1 ton/acre (Cooper et al., 1957). When meadow and range production was compared, ADG of calves was consistently higher when the cow-calf pairs were on meadow. Yearlings on range, however, gained slightly more until July 10. After July 10, steers on meadow gained 1.2 pounds/head/day more than steers on range (Table 5). Total average gains were 244 and 180 pounds per steer for those on meadow and range respectively.

Grazing on some meadows has been discouraged because of fragile soils. In the sandhills of Nebraska, grazing sub-irrigated meadows has been a questionable practice. Clanton and Burzlaff (1966), however, observed that such meadows can be grazed without deterioration or loss of productivity. Their studies indicate that the meadows can be grazed every third year and hay produced the other 2 years. This could be done in a rotational management system. They cautioned not to graze a meadow in consecutive years. Yearling cattle were considered best for grazing meadows during the growing season. In the early winter, cows could be used for cleanup. Where meadows are grazed, it was also recommended that clovers be introduced into the stand and that the meadow be fertilized every fourth year with elemental phosphorus at the rate of 20-25 pounds/acre.

Apparently, forage from fertilized meadows is not used as efficiently when grazed as when fed as hay (Rumburg, 1961). In this study, grazing animals gained 11 pounds/acre more from the unfertilized than from fertilized pasture. The pastures were stocked with one yearling per acre on fertilized pasture and one yearling per 2 acres on unfertilized pastures. The ADG was 1.8 pounds for both groups, but steers on pastures fertilized with 80 pounds nitrogen per acre were removed early because of scarcity of forage.

The concentration of crude protein in forage from the fertilized pastures was 3.7 percent higher on May 4 and 1.1 percent higher in June than it was in forage from the unfertilized pastures. The difference in concentration at the two dates suggests that most of the fertilizer-N had been taken up by the plants and grazed by the steers. Thus, early removal of the nitrogen from the soil-plant system prevented its being available for plant growth later in the season. It, therefore, was not available at the same degree as if it were not grazed. These data suggest that a greater return from investment in fertilizer could be made when the fertilizer went toward hay production than to increase forage for grazing.

SUMMARY

Improving meadow forage production is a worldwide problem. Under native conditions, the plants adapted to seasonally wet soils produce about 3/4 ton/

acre. The water requirement for these species is high, being 1 to 12 acre feet for each ton of wild hay.

Research has shown that low-producing rushes increase when meadows are flooded for longer than 50 days or deeper than 5 inches. Also, the height of the water table at the beginning of the growing season apparently has as much affect on the species composition of the stand as does the average depth of water table. One of the most critical periods of flooding appears to be late June.

Because of the low production of rushes and sedges, the control of water level is probably the most important factor in the management and improvement of wet meadows. Intermittent irrigation practices can increase yields to 4 ton/acre and reduce the water requirement with introduced species to 7 acre-inches per ton of forage.

With the one-cutting system, hay should be cut at the flowering-to-soft-dough stage. Since the forage is losing about 0.1 percent crude protein per day, the quality of the hay and the feeding value are decreased in a short time. Cutting hay late results in lost quality and animal performance. Cutting twice during the season may reduce the total dry matter yield on some meadows, but the quality of the feed and the total protein yield usually will be greater. Grazing early, when harvesting a cutting of hay, will increase the hay quality and the total forage yield should be similar to that of the one-cutting system.

Native meadow forage should be cut as low as possible. Raising the stubble height from 2 inches to 4 inches may result in a 40 percent loss in total yield.

Fertilizers are effective in increasing the hay yields and the water use efficiency if the plant water requirement is met. Grasses respond most to nitrogen, and legumes respond to phosphorus and to potassium where these elements are deficient. The concentration of crude protein in hay resulting from fertilization with nitrogen depends on the time of harvest. In normal haying operations, the crude protein concentration of the herbage from fertilization is similar to that obtained without fertilization. Because the vigor of grasses is stimulated by nitrogen, they may compete severely with legumes which may be important components of the sward. Care should be taken to prescribe a fertilizer program that will increase the production of both legumes and grasses when the production of the legume is desired.

The most efficient rate of fertilization with nitrogen appears to be 80 to 100 pounds/acre. At these rates, 1 pound of nitrogen produces 20 to 25 pounds of additional hay. The source of nitrogen at normal rates of application has no significant effect on yield or chemical composition; therefore, the most economical source of nitrogen should be used. Application of fertilizer should be delayed until it is determined that sufficient irrigation water will be available during the growing season. Where fertilization with phosphorus is desired, application of 20 pounds of P per acre is recommended.

Grazing on meadows may be an important source of feed. Oregon meadows have a carrying capacity of about 3 AUM/acre during a 5-month period. Spring grazing followed by haying, and haying followed by late fall grazing are also important alternative uses of meadows.

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Table 1. Forage quality and digestibility as affected by plant maturity[1/]

Date of harvest	Crude protein	Protein digestibility	Digestible protein
	%	%	lb/ton
June 21	9.9	64.1	127
July 5	8.9	64.2	114
July 19	8.1	58.2	94
August 2	6.8	46.7	64
August 9	6.3	39.5	50

1/ Original data were presented by Raleigh et al. (1964).

Table 2. Hay yield and quality as affected by cutting height[1/]

Cutting height	Hay yield	Protein concentration
inches	ton/acre	percent
2	1.56	6.15
4	0.94	6.46
6	0.33	6.68

1/ Data were originally presented by Cooper (1956b).

Table 3. Dry matter yield and crude protein in meadow hay as affected by number of cuttings per season[1/]

System of harvesting	Dry matter yield	Crude protein concentration	Crude protein yield
	ton/acre	percent	lb/acre
One-cutting	3.00	9.3	558
Two-cutting	3.12	14.3	892

1/ Average of six fertilizer treatments; adapted from data presented by Hunter (1959).

Table 4. Expected cost and return of meadow hay with fertilizer applied to meadows of eastern Oregon[1/]

Fertilizer rate	Expected hay yield	Yield of hay per lb of N	Cost of fertilizer per ton of increase forage[2/]
lb N/acre	ton/acre	lb	dollar
0	1.83	--	--
50	2.62	31.6	9.49
100	3.05	24.4	12.29
150	3.34	20.4	14.90
200	3.66	18.3	16.39

1/ Pooled values of studies (Cooper, 1955; Cooper and Sawyer, 1955; Nelson and Castle, 1958).

2/ Determined at 15¢/lb of nitrogen.

Table 5. The average daily gain of yearlings at two grazing periods on meadow and range forage[1/]

Pasture type	Average daily gains by yearlings May 20 to July 10	Average daily gains by yearlings July 10 to September 10
	lb	lb
Meadow	1.62	1.84
Range	1.76	0.65

1/ Data were originally presented by Cooper et al. (1957).

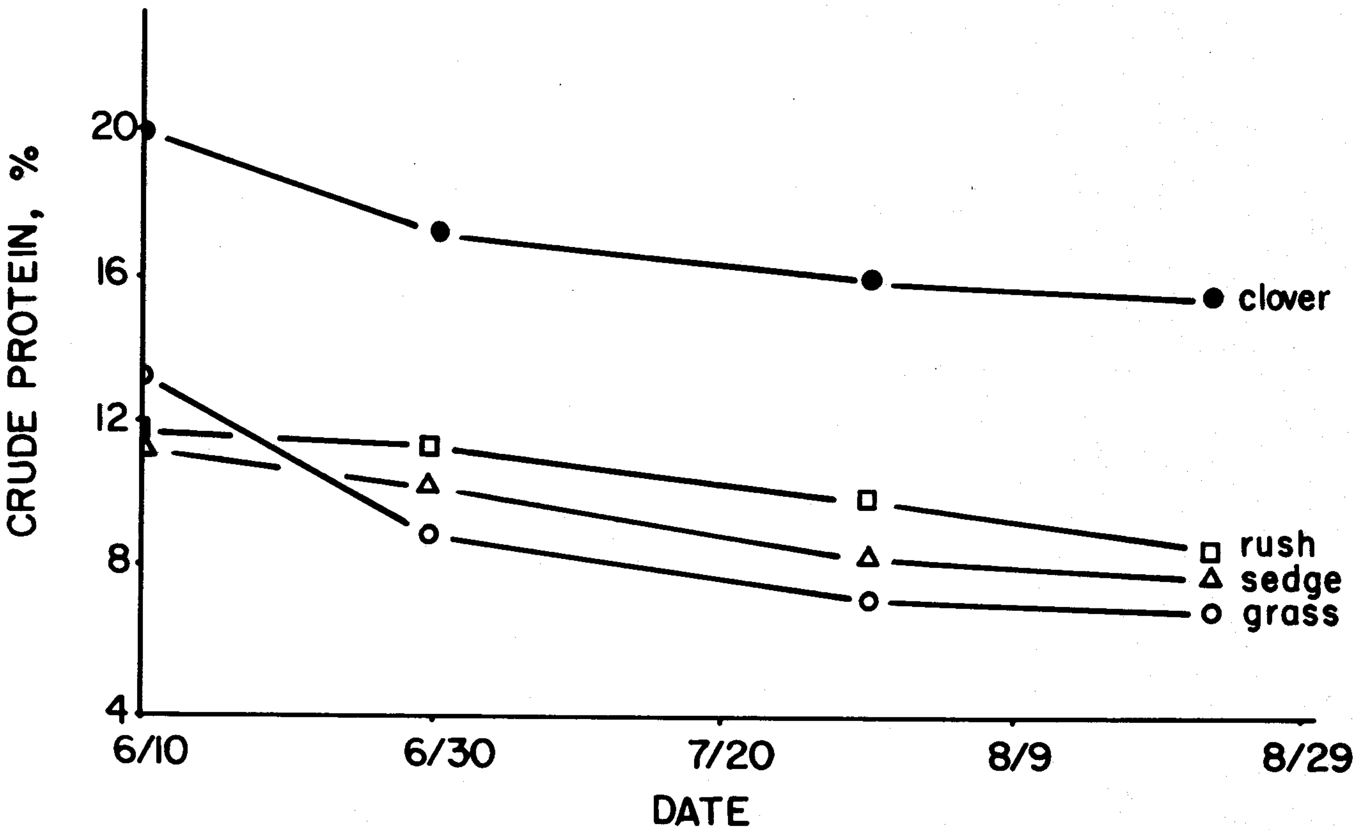

Figure 1. Concentration of crude protein in meadow plants at different dates of harvest. Adapted from data of Miller and Amemiya (1954).

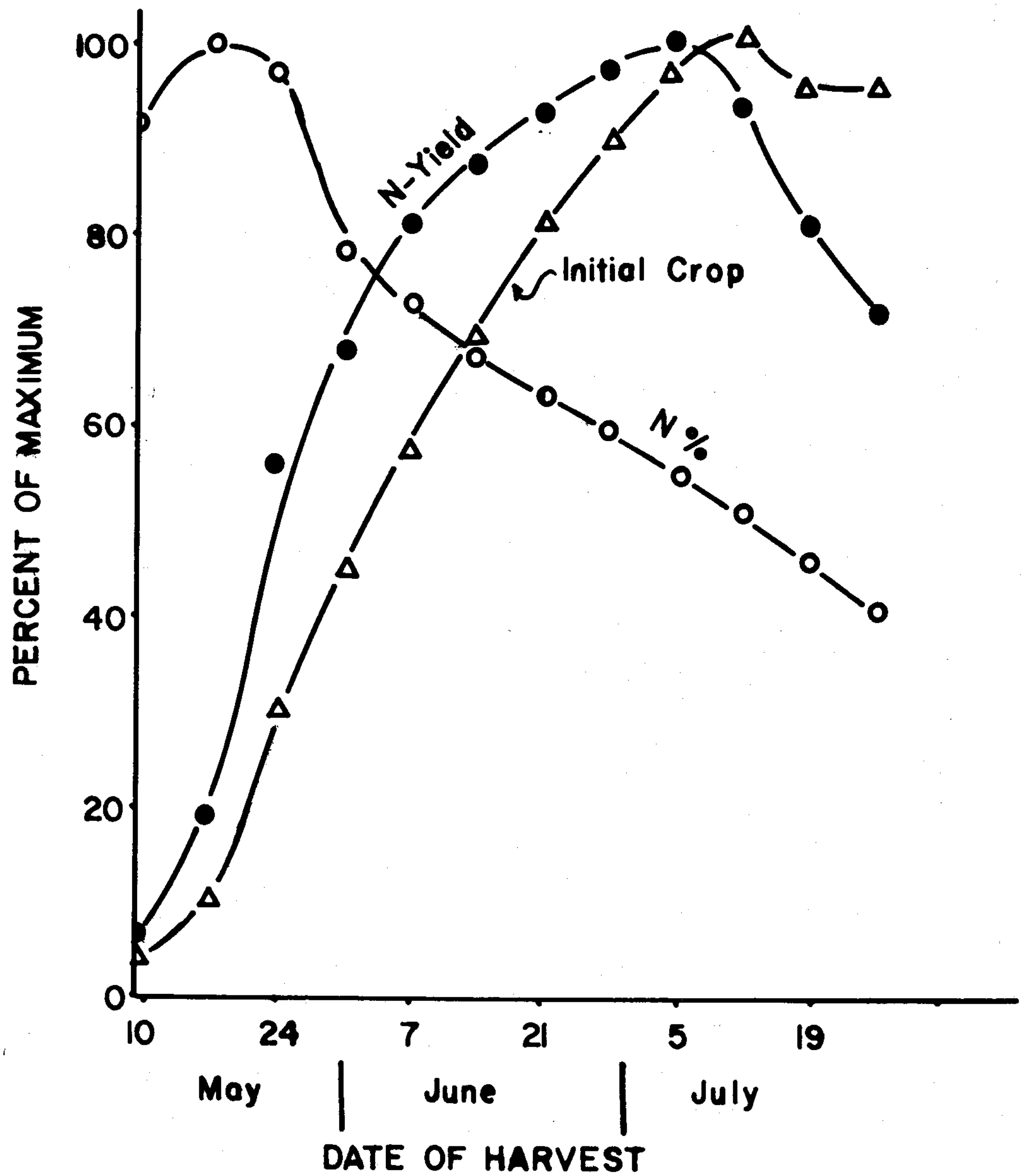

Figure 2. Seasonal distribution of dry matter yield, N concentration and total N yield in fertilized meadow forage. Originally presented by Rumburg et al. (1964).

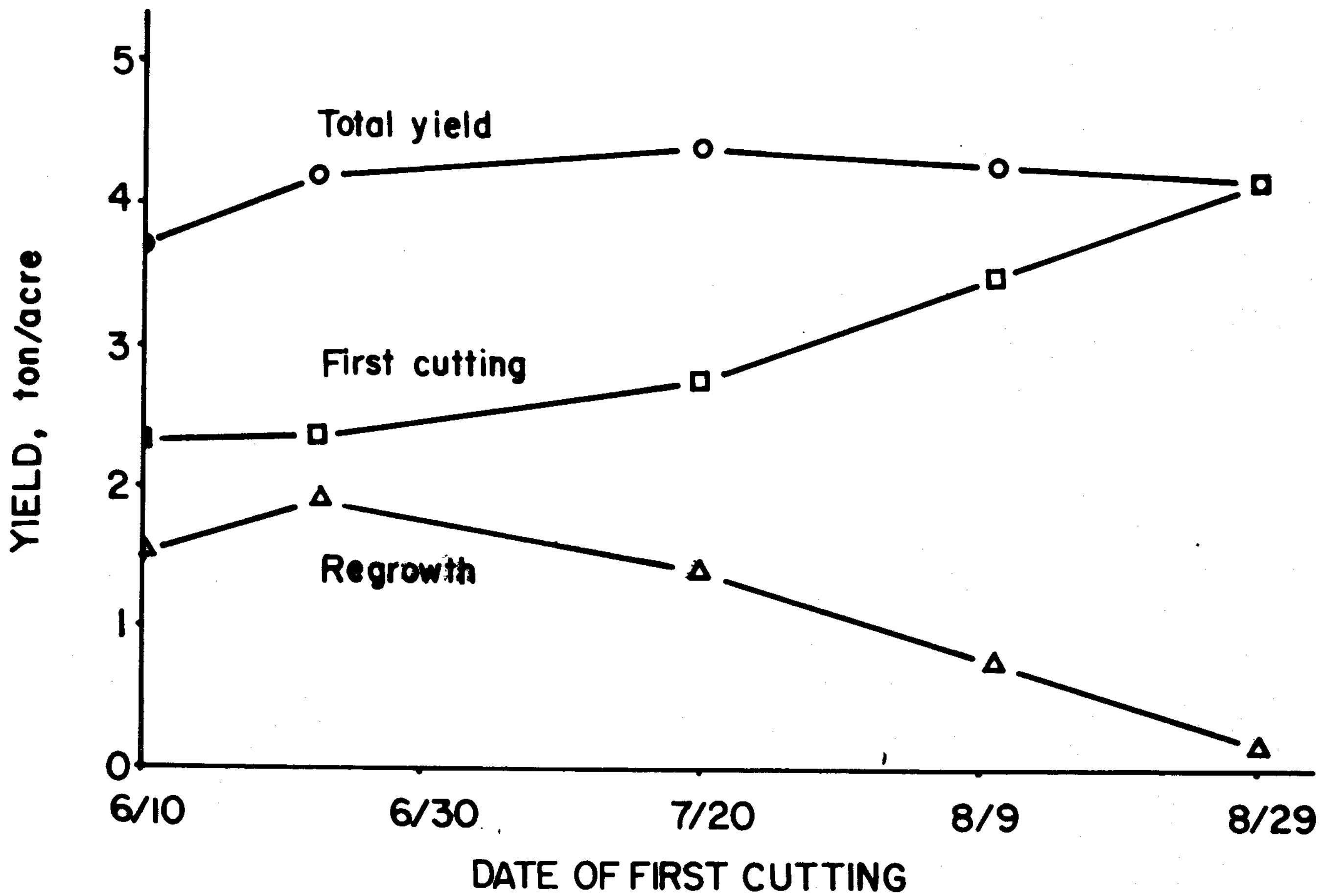

Figure 3. Dry matter harvested in the initial cutting, regrowth, and total yield of introduced grass as affected by date of initial cutting. Adapted from data of Miller and Amemiya (1954).

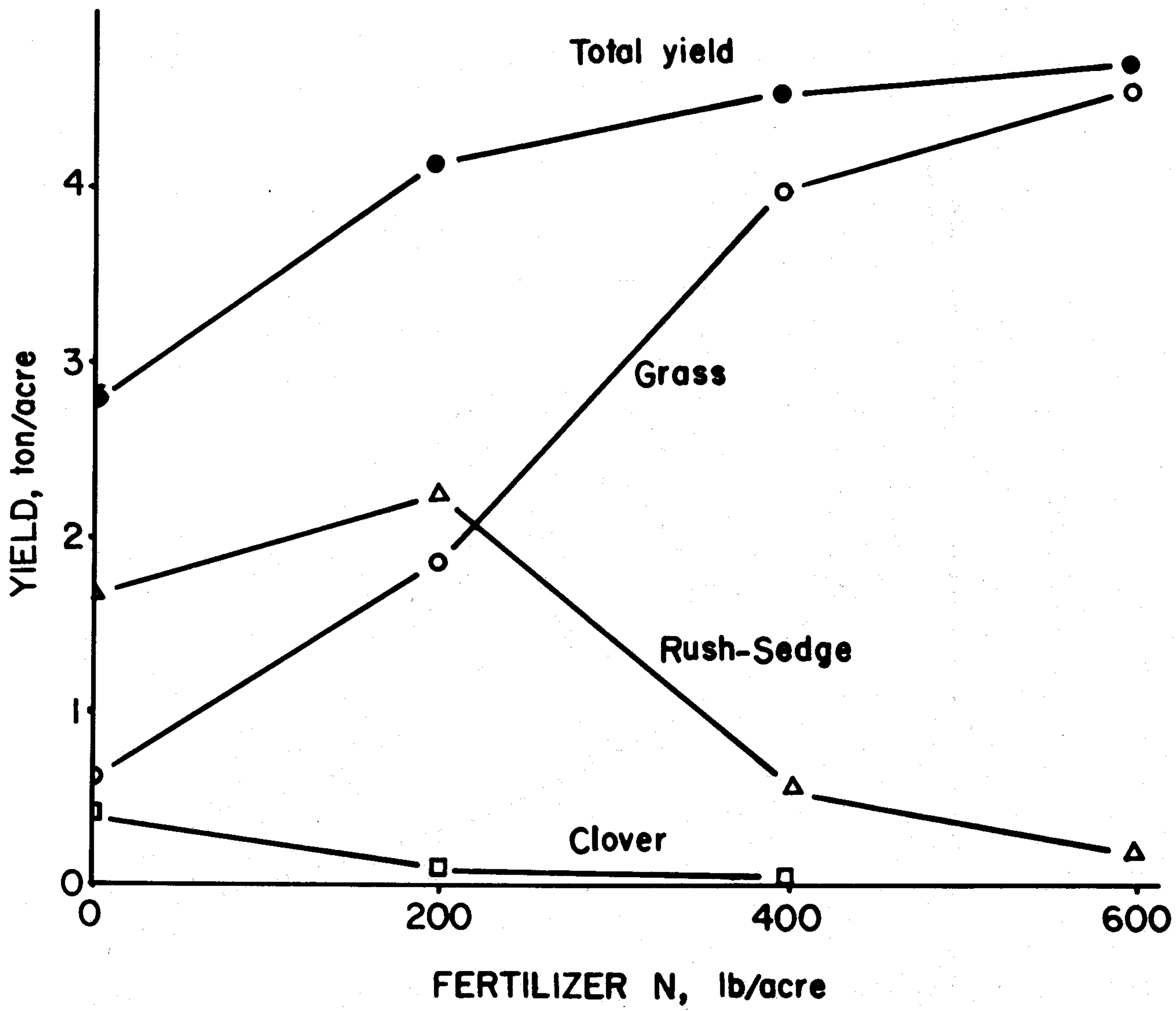

Figure 4. Yields by species components in response to nitrogen fertilizer. Original data were presented by Rumburg and Cooper (1961).

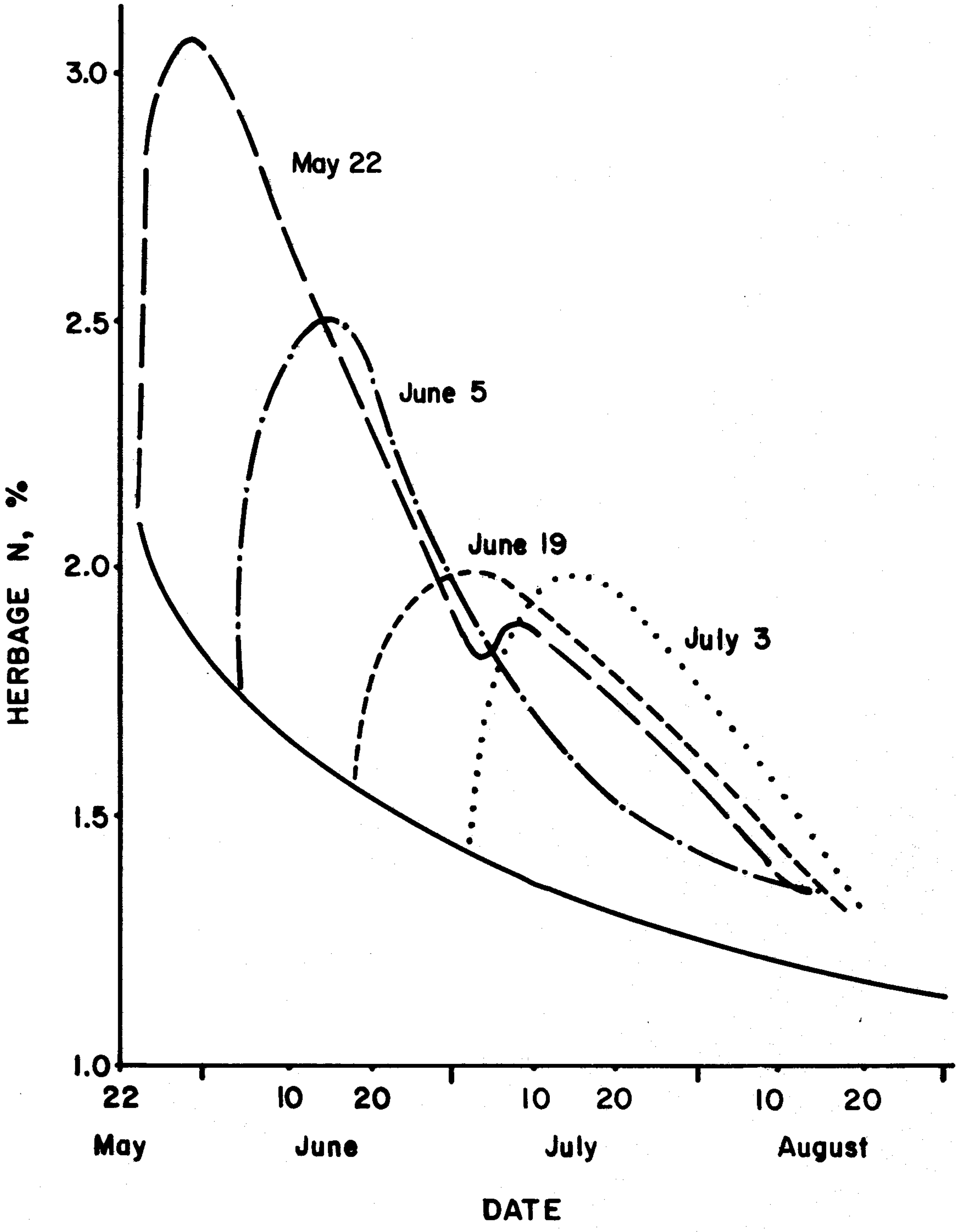

Figure 5. Nitrogen concentration in herbage resulting from fertilization with 100 lb N/acre at different dates. Adapted from Rumburg (1972).

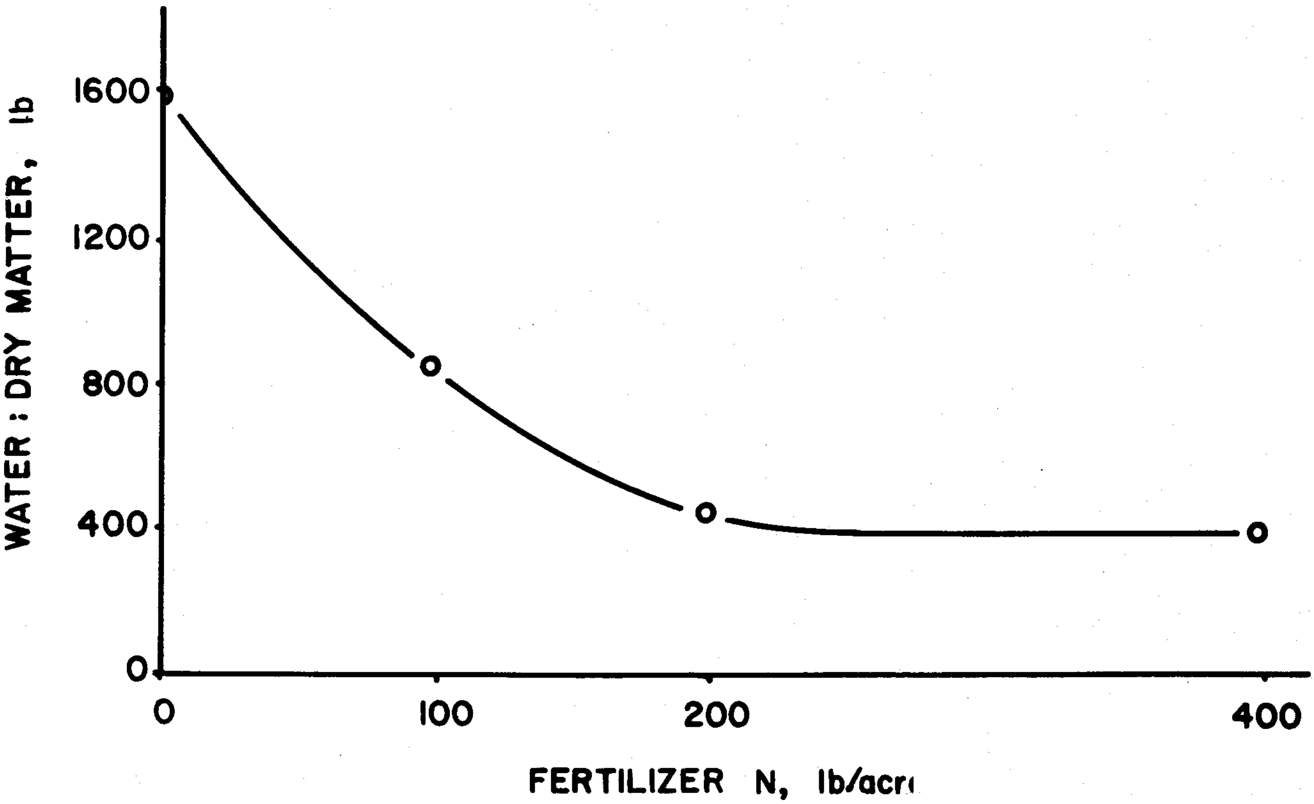

Figure 6. Water use efficiency ratio as affected by fertilizer when soil moisture is not limiting growth.