Phalaris "Staggers" in California

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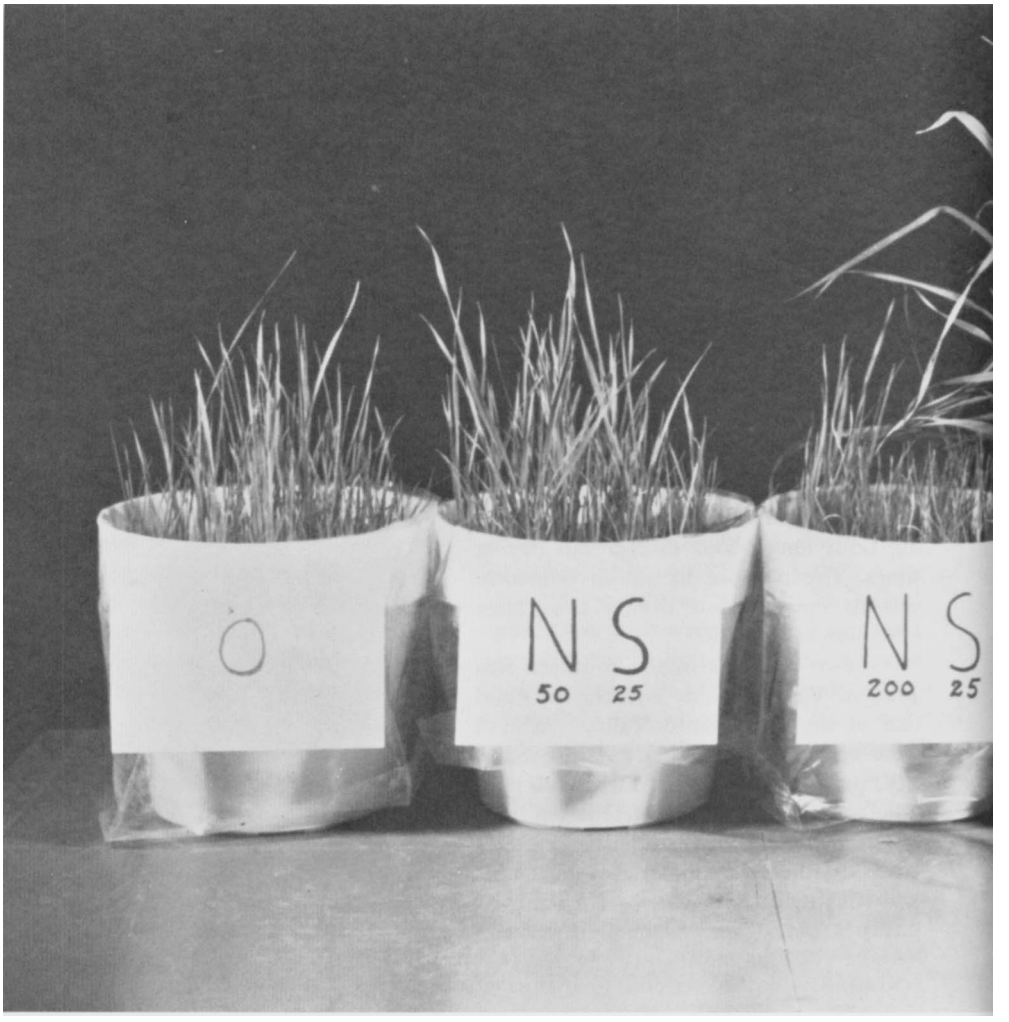

Fig. 1. Growth of Hardingrass in Timmons loam to which various fertilizers were added.

Stock grazing on pastures in which *Phalaris* species are the predominant grass have on occasion developed what appears to be a neurological disorder which results in the "staggers," a term used to describe their unsteady, stumbling gait. Other manifestations include restlessness, hyperexcitability, twitching of the ears, head bobbing, jaw tremors, heavy breathing, and an excessively high pulse rate. When driven, the animals are often unable to unflex their forelimbs and they collapse. The pathological features associated with the disorder have not been well defined, although some degeneration of tracts in the spinal cord and haemosiderosis of the kidney have often been observed. Heavy losses of animals have occurred.

Australian research

One of the *Phalaris* species in California, Hardinggrass (*Phalaris tuberosa* cv. stenoptera), was introduced from Australia. It was in South Australia, in 1942, that reports of the "staggers" resulted in studies involving the application of a number of nutrient elements to the pastures in which the disorder occurred. These revealed that cobalt had the most beneficial effect. Subsequently, a cobalt "bullet" was developed which, when placed in the rumen, proved effective in supplying this element to animals throughout a grazing season. That "staggers" was not a case of simple cobalt deficiency, however, was indicated by the fact that vitamin B_{12}, the only physiologically essential form in which cobalt is known to be needed by ruminants, did not provide any benefit. In addition, this element did not provide protection against another form in which the disorder appeared. These were cases in which the animals developed acute symptoms in much less time than was usual after being placed on the pasture.

California reports

Several cases of "staggers" in which *Phalaris* species have been implicated have been reported in California. In the early 1960's nervous disorders were observed among cattle grazing canarygrass *P. minor* in winter in the Imperial Valley. Subsequently, U.C. scientists V. E. Mendel and G. L. Crenshaw found that juice extracted from the grass and infused into fistulated animals daily for 20 days did not produce the symptoms previously noted in the grazing animals. In the winter of 1966 to 1967, sheep grazing a Humboldt County pasture showed "staggers" symptoms similar to those reported from Australia. Several animals died. A test involving use of cobalt bullets was set up late in the grazing season by Farm Advisor John Dunbar. No benefit of treatment was observed in sheep affected with "staggers." Other isolated cases of losses of sheep and cattle grazing Hardinggrass have been noted but whether these were cases of "staggers" is not certain. No "staggers" symptoms were observed in a three-year sheep grazing trial conducted by R. M. Love and W. C. Weir on Hardinggrass pasture near Davis, California.

The manner in which the disorder manifested itself indicated a possible toxin in the grass. Investigation by Australian researchers led to identification of several tryptamine alkaloids in *Phalaris tuberosa*. These included N,

N-dimethyltryptamine (DMT), 5-methoxy-N, N-dimethyltryptamine (5-MDMT), and 5-hydroxy-N, N-dimethyltryptamine (5-HDMT), also known as bufotenine. Because of their known pharmacological properties, it seemed likely that one or more of these biogenic amines could be causing the problem. Parenteral administration of small doses of these compounds caused profound disturbances in the central nervous system and produced some acute "phalaris staggers" symptoms. Dosages greater than 1 mg per kg of body weight often resulted in acute heart failure. Lower dosages produced hyperexcitability, salivation, head nodding, pupil dilation, poor coordination, and lateral recumbency.

Humboldt County studies

For several years this animal disorder has been studied in Humboldt County by the Department of Soils and Plant Nutrition and by Cooperative Extension staff members in Animal Science, the School of Veterinary Medicine, and the county. These studies have been directed towards determining the role of alkaloids in the disorder, soil and environmental factors that can affect plant composition, and development of management practices to minimize or eliminate the problem. It seemed likely that *Phalaris* would become more widely used, thus increasing problems of grazing animals were anticipated. The strong possibility that soil and climatic factors, independently or through interaction, were involved was indicated by the fact that the disorder occurs only in certain areas and is much more severe in some seasons.

Examination of plant tissue extracts by paper chromatographic techniques revealed that both DMT and 5-MDMT were present in Hardinggrass samples from Humboldt County, with DMT indicated as occurring at a much higher concentration. Subsequently, a quantitative colorimetric method for determining these two alkaloids was developed. Several sheep were injected with 5-MDMT; symptoms similar to those reported by the Australian researchers were noted. Although the animals were severely immobilized almost immediately upon injection, recovery occurred within a few hours; by the following day no symptoms were evident. Some "staggers" symptoms observed in affected sheep in the field persisted for much longer, with some never fully recovering.

Results of greenhouse studies showed that under some conditions of growth the concentrations of alkaloids in the grass were higher when nitrogen was supplied in the ammoniacal form than in nitrate. Differences in the rate of nitrification—because of environmental conditions—would be one factor that could account for inconsistencies in the experimental results. A better understanding of the biosynthesis of these indolealkylamines will have to be developed before any observed differences in effects of ammonium versus nitrate on the occurrence of these plant constituents can be explained physiologically.

Field studies

A ten-acre pasture on the John Mitchell ranch near Garberville was divided into halves. The soil is mapped as Timmons loam. This pasture had been fertilized with 16-20 prior to 1964 when Hardinggrass was sown. In the winter of 1966-1967, sheep developed "staggers" on this pasture so it was not grazed during 1967-1970. Beginning in the fall of 1971, except for one year, fertilizer was broadcast on one plot or the other, and sheep were placed in the pasture in late fall. Animals were provided by Mr. Mitchell, members of the Humboldt County Wool Growers' Association, and the Hopland Field Station. During each of the four seasons studied, forage samples were collected from the plots and analyzed for alkaloids as well as other nitrogen components.

Results did not show any clear correlation between the occurrence of alkaloids and the incidence of "staggers." Concentrations of alkaloids were highest in the early part of the grazing season, but most animal losses occurred at midseason. Forage grown on plots receiving ammonium sulfate where the disorder was most severe did not have higher concentrations of alkaloids. In the seasons when losses from "staggers" were low, concentration of alkaloids in the forage did not seem to be greatly different from those years in which animal losses were much higher. Possibly the animals grazing the nitrogen fertilized plots were ingesting more Hardinggrass, because this fertilizer treatment favored the growth of the grass species over that of the clover. Collection of samples from fistulated animals would be necessary to confirm this.

Results obtained in the 1974 to 1975 season provided good evidence for the involvement of cobalt. The most severe "staggers" and all of the sheep deaths occurred in the group grazing in a pasture which received a P-containing fertilizer (27-12) and did not receive a cobalt supplement. The obviously much better growth of forage on this pasture is attributed to phosphorus rather than to the difference in N application rates because there was no difference in the N content of the forage from the two pastures, and previous greenhouse studies had shown a marked response to P.

Before the period "staggers" symptoms appeared and deaths occurred, the concentration of cobalt in the forage was lower in the pasture which received the P-containing fertilizer. This difference in the forage in the two pastures was particularly great during December. Based on cobalt analysis of the grass, one might expect that the problem would become more severe in spring. This has not been

the case. One possible explanation is that other species, which become more prevalent as the season progresses, have higher concentrations of cobalt. For example, other investigators have reported higher concentrations of cobalt in the legumes growing in mixed grass-legume pastures. Samples of other species growing at the plot site should be collected and analyzed in subsequent studies.

Question remains

The question of why the disorder occurs with such severity at this site and not in other areas where Hardinggrass is used for grazing sheep has not been answered. Not enough samples have yet been analyzed to provide good comparisons. If lack of sufficient cobalt is the causative agent, it must also be explained why the deficiency is manifested as "staggers" when animals are grazing Hardinggrass. These are not the same symptoms as have been reported in cases of simple cobalt deficiency.

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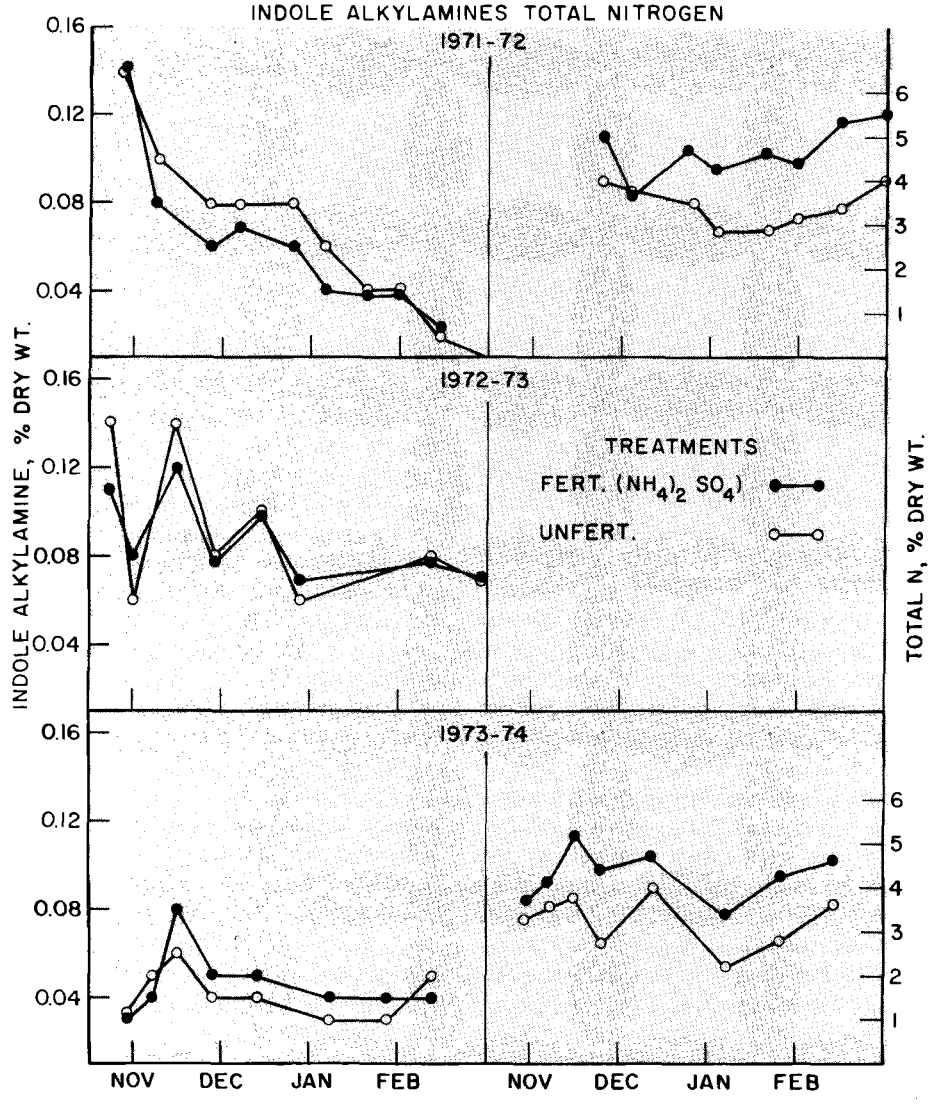

Fig. 2. Concentrations of indolealkylamines and total nitrogen in Hardingrass samples collected during three seasons. Total nitrogen was not determined in 1972 to 1973.

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A Crown

California's coast, from Salinas to San Diego—one of the few areas in the United States that produces celery throughout the year—is now threatened with a soil-borne disease. To date, it has been observed in Orange, Ventura, and San Luis Obispo counties.

When the disease first appears in a circular location within a field, plants at the core of the affected area are severely yellowed and stunted; those at the margins are only slightly affected. In later years the affected area enlarges in size and increases in number. Disease incidence is high in summer but low in winter. Growers' observations suggest that extensive spread within a field may occur within three years, probably because fields are normally land-planed after each crop. In some fields 90 to 100 percent of the plants have been affected, and growers have been forced to move to new locations. (An estimated 440 acres in celery in Orange County alone have been abandoned.) Most of California's acreage is planted to Tall Utah 5270 R, a variety highly susceptible to the disease.

The initial symptom is a lag in growth, usually followed by yellowing of foliage. The water-conducting tissues of the roots, crown, and petiole are orange to brown in color (see fig. 1). A brown to black dry rot of the internal crown tissues is often present as well (see fig. 2).

Investigations of the cause of the disease (by L. P. Hart and R. M. Endo) to date indicate that the disease is the *Fusarium* yellows disease caused by *F. oxysporum* f. sp. *apii*. Steam sterilization of naturally infested field soil collected from San Luis Obispo, Orange, and Ventura counties eliminated the pathogen