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Perennial Grasses for California Rangelands

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ABSTRACT: Perennial grasses have been used for many years to improve livestock forage on California's annual-type grasslands and chaparral brush burns but with limited success. The potential value of perennials lies in their ability to extend seasonal green forage beyond that supplied by resident annuals(mostly alien annual grasses and forbs). However, perennial grass establishment and performance suffer from the same extremes of weather that affect annuals, plus perennials are not very competitive as seedlings. Lack of proper management of established stands also has been a problem. Even introduction of the much improved Perla koleagras (to replace the widely used hardinggrass) has failed to attract rancher interest; most range operators today are not willing to risk the investment required to improve and reseed ranges to perennials. This paper reviews these problems in the context of the ecosystem in which these grasses must function and discusses selection and breeding of two genera and their use outside California.

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Rainfall and nitrogen are the dominant factors limiting herbaceous forage production on California's annual-type grasslands. A Mediterranean-like climate dominates nearly 60 percent of the state and is characterized by hot dry summers, mild rainy winters, and a high percentage of sunny days throughout the year. Average annual precipitation ranges from 6 in (150 mm) in the southern part of the state to more than 75 in (1900 mm) in the north coast region. Snowfall is limited and occurs only at higher elevations inland.

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Unike other grassland areas of the West, California gets nearly all its precipitation during winter. The growing season may vary from three to eight months, depending on the date of the first significant rain in autumn or early winter, and when soil water from the last spring rain is depleted.

Growth of herbaceous forage plants in California is strongly affected by temperature extremes and moisture stress. Plants must tolerate cool winter temperatures which are marginal for growth and, at the same time, soils at or near saturation with associated poor aeration. In summer, these same plants must survive desert-like conditions of extreme dryness and high temperature. Annuals avoid these conditions by maturing seed at the beginning of the dry season, while perennials go into summer dormancy.

In 1937, the University of California's Agricultural Extension Service (now Cooperative Extension) in cooperation with the Division of Agronomy at Davis (now Department of Agronomy and Range Science) began testing plants for range improvement throughout the state (Jones and Love, 1945). In county trials, nearly 200 species were included in this program. Exotic perennial grasses were included to extend the green-forage season and thereby forage quality. By 1945, it was evident that few perennials were widely adapted. Because of limited adaptation and subsequently low demand for seed, only a few species have been and are recommended for range improvement today.

HARDINGGRASS

Hardinggrass (Phalaris tuberosa[1] var. stenoptera) has been the most widely planted perennial forage grass for range improvement in California's annual grassland and chaparral shrubland ecosystems. The species is indigenous to northern Africa. It was introduced to Australia from the Union of South Africa, from whence it was carried to the United States in 1914 and first planted by the California Agricultural Experiment Station (Hanson, 1972).

Hardinggrass is a long-lived, persistent, dryland perennial bunchgrass with short, stout rhizomes originating from the base of a prostrate crown. It provides some winter growth but does not withstand hard frosts.

Within California, hardinggrass will survive where average annual rainfall is 16 in (400 mm) if the soil has high water-holding capacity (Hanson, 1972). Its ability to do well on light soils with good water-holding capacity in the subsoil has made hardinggrass useful for seeding brush burns. However, the best stands occur on deep soils with high water-holding ability or where rainfall is ample, well above 16 in (400 mm).

[1]Phalaris tuberosa is included in the name, Phalaris aquatica, used in recent literature.

The most widely used strain of hardinggrass was collected in 1940 from one of the University of California's trial plantings and was put under an intensive testing program by staff of the Soil Conservation Service Plant Materials Center, Pleasanton, California. Results of this study of the plant's drought resistance, winter growth, perennial character, and palatability led to certification of hardinggrass in 1946 by the California Crop Improvement Association (Hanson, 1972). Certification and large-scale production of seed at reasonable prices encouraged considerable use.

The great value of hardinggrass is its long green season, i.e., its ability to break summer dormancy and begin growth before the first fall rains and then to remain green until after seed has matured in early summer. It thus can provide green feed several weeks longer than the resident native and naturalized annual grasses. In this respect, it even surpasses many of the native perennial grasses (such as purple needlegrass [Stipa pulchra] and nodding needlegrass [S. cernua]) (Dickey, undated). This extended green feed period helps reduce nutritional deficiencies on California's annual-type grasslands.

This behavioral pattern of hardinggrass is due, apparently, to stored carbohydrates in bulbs or corms at the base of the culms, hence its specific name tuberosa. However, no plant is without fault, and hardinggrass is no exception. The chief problem has been poor stand establishment. Its weak seedlings compete poorly with the more vigorous seedlings of annual grasses. The best stands are obtained by fall seeding on well prepared beds fallowed the previous spring and summer or after a brush burn. Because many seedings have not met these more ideal conditions, only a limited number of successful stands have been established.

Hardinggrass' ability to survive under droughty conditions has made it useful for seeding after brush burns. It germinates readily in the ash and takes advantage of the reduced annual plant competition on these sites; seed reservoirs are usually minimal on chaparral sites. Hardinggrass was favored in such situations, as any successful perennial would be, because it provides a larger and more stable forage resource and less yearly fluctuation than annuals. Hence, its longevity, productivity, palatability and drought tolerance have made it the favored perennial grass for brush burn seedings throughout much of the state until the 1970's (Love and Jones, 1952; McKell et al., 1965). At that time, a new, much improved variety of the species, Perla koleagrass, (P. tuberosa var. hirtiglumis), was introduced. Although now replaced by the new cultivar, hardinggrass pioneered the practice of seeding for range improvement in California.

A series of brush range improvement demonstrations was begun by the University of California in cooperation with the California Department of Forestry and livestock operators in 1950. Their purpose was to test and demonstrate field-scale application and economics of management techniques and foster the spread of these practices through practical applications. The results of one of these demonstrations can help one appreciate the impact seeding can have as a range improvement practice in California. On the Aldridge Ranch, 35 mi (56 km) east of Redding in northern California, about 3500 ac (1400 ha) of woodland chaparral was

burned, and a variety of annual and perennial legumes and grasses, included hardinggrass, was seeded on 1000 ac (400 ha) where the fire burned with greatest intensity. Hardinggrass yielded up to 8100 lb/ac (3700 kg/ha) of dry forage with a crude protein level of 7.1% (Myler and Street, 1954). The ranch carrying capacity increased 300% to nearly 1200 AUMs a year after burning and seeding, with grazing capacities reaching nearly 0.4 AUM/ac (1 AUM/ha). The return on investment varied from 22% to 48% each year (average 41%), and the project more than paid for itself by the end of the third year. Total return on investment by the seventh year reached 266% (Kay et al., 1959; Myler and Street, 1954).

At another site on Sierra Nevada foothill woodland-grass range, Kay (1969) found that seeded annual clovers doubled total forage production (5300 vs 2700 lb/ac [6000 vs 3000 kg/ha]) and that total production was increased an additional 13% (700 lb/ac [800 kg/ha])--most of which was valuable winter feed--when hardinggrass was included in the mix.

However, these results imply that hardinggrass has had a far greater impact on range improvement in California than actually has been the case. For example, substantial amounts of certified Phalaris seed (mostly hardinggrass) have been produced since 1946 (California Crop Improvement Association, undated; Lockeford Plant Materials Center, undated). Assuming a 4 lb/ac (4.5 kg/ha) seeding rate, 500,000 ac (200,000 ha) may have been planted with certified hardinggrass between 1946 and the release of Perla koleagrass. Furthermore, estimates by knowledgeable sources of the amounts of uncertified seed produced in California and imported suggest the total area seeded may have exceeded 750,000 ac (300,000 ha). Unfortunately, most seedings have failed for a variety of reasons. Field observations indicate one-in-three hardinggrass seedings failed to establish because of year-to-year extremes in seasonal weather patterns, such as periodic drought or frost. Another third failed because of poor seedbed preparation and competition from annuals during the year of establishment. The remaining one-third largely failed to develop adequate stands for one of three reasons: (1) changing land use patterns (subdivision and farming of rangelands); (2) inability of landowners and managers to incorporate the management needs of perennial grass into their management of annual grasslands, usually season-long grazing; and (3) planting of hardinggrass where rainfall and soil conditions were inappropriate to sustain the plant under recommended grazing management.

PERLA KOLEAGRASS

Perla koleagrass, the suggested replacement for hardinggrass, was developed by the USDA Soil Conservation Service Plant Materials Center, Pleasanton, after introduction from Morocco. Similar in appearance to hardinggrass, it is a tall, vigorous bunchgrass with short rhizomes. Three advantages of perlagrass over hardinggrass are greater seedling vigor, higher winter production, and better survival. Perla has a larger seed, but its distinguishing taxonomic characteristic is its hairy glumes (Adams et al., 1974).

Testing of the new grass began in 1956. Based on cooperative evaluation by the Soil Conservation Service and the University of California Agricultural Experiment Station, Perla was accepted for certification in 1970 by the California Crop Improvement Association (Adams et al., 1974).

Unfortunately, Perla koleagrass has since contributed very little to range improvement in California, because it entered the picture when financial returns from ranching were on a decline, and income from seed production was not competitive with that from other enterprises. Given the problems of establishing and maintaining a perennial grass in the annual grassland ecosystem, and the continued, poor economic prospects for the ranching industry, Perla probably will play only a limited role in range improvement in California for the forseeable future.

OTHER PHALARIS CULTIVARS

Development of new varieties of Phalaris for range seeding has been by selection and breeding, mostly the former. In California, hardinggrass and Perla are examples of selections for drought tolerance (summer dormancy) and winter productivity. In Texas, the release Wintergreen (P. tuberosa var. stenoptera) was chosen for its ability to survive extended drought and high temperatures (Hanson, 1972) while, in Australia, researchers produced the selection Sirocco (P. tuberosa), which is very similar to Perla (Hutton, 1970).

Phalaris breeding has been primarily an Australian enterprise with emphasis on increased seed production and retention (Hutton, 1970; McWilliam and Gibbon, 1981). Unfortunately, a number of the Australian Phalaris cultivars, including Seedmaster, failed when tested on California rangelands.

What breeding there has been of Phalaris in the United States has occurred in the southeast. There, selection has emphasized cool-season, disease resistant grasses with good yields of high quality forage in autumn and winter, to produce animal gain equal or superior to that from annual ryegrass and tall fescue (Hoveland et al., 1982; Pederson et al., 1984; Pederson et al., 1983).

In spite of the various selection and breeding programs, only hardingrass and Perla have continued to be recommended in California.

ORCHARDGRASS CULTIVARS

Summer dormant orchardgrass (Dactylis glomerata) has seen limited use for range improvement in California since the release of the cultivar Palestine in 1968 (Hanson, 1972). Its greatest use has been for reseeding brush burns in the north coast, although it is adapted throughout all northern California foothill areas below about 3500 ft (1070 m). Perhaps the greatest amount of seed is sold for environmental purposes, such as roadside stabilization, or for low-maintenance groundcover for parks where it requires no irrigation and only a single mowing per year to maintain a satisfactory appearance.

The advantage orchardgrass has over Phalaris cultivars for grazing is in ease of establishment. Orchardgrass has excellent seedling vigor and at the same time almost twice as many seeds per unit of weight. Winter forage yields are superior to resident annual grasses but may be considerably less than hardinggrass or Perla.

The orchardgrass cultivar, Berber, has been tested by the University of California at Davis and the Soil Conservation Service since 1968. It has proven superior to Palestine in survival and forage production. Berber originated from a sample of seed obtained by B. L. Kay from J. H. Silsbury of Waite Agricultural Institute in South Australia. It had been derived in Australia from a line designated GL-34. Australian interest in the cultivar waned beause of low seed yields and limited economic returns to graziers. Foundation seed has been available from the California Crop Improvement Association since 1981.

Other dryland orchardgrasses have occasionally been obtained from Australia, but they have not persisted in California field plantings. For example, cultivars Brignoles and Currie showed insufficient summer dormancy, and Kasbah, although more summer dormant than Berber, proved inferior in other ways.

Outside California in the Intermountain West, Paiute orchardgrass first became commerically available in 1984 for use on range seedings, although it has persisted in trials for as long as 30 years on rangelands of Arizona, New Mexico, southern Idaho, Utah, and Wyoming where precipitation is 10-25 in (350-640 mm). Paiute is also suggested for use on mine spoils and as a cover crop in irrigated orchards in the above states (Monson and Stevens, in press).

The most commonly seeded cultivars of orchardgrass on rangelands of the Intermountain West have been Potomac and Latar. Common orchardgrass from Canada (no variety name) also is seeded and has performed well in the mountain brush and aspen vegetation types (Stevens, 1984, Pers. Comm.).

SMILOGRASS

Smilograss (Oryzopis mileacea) was used for seeding chaparral burns below 3000 ft (900 m) in California from the 1940's until the early 1960's. It is particularly successful on sites formerly occupied by the shrub chamise (Adenostoma fasciculatum). Smilograss is a hardy, drought resistant, palatable, long-lived perennial bunchgrass native to the mountains of southern Europe and the Mediterranean where it is found on dry soils bordering the woods (Love, 1947).

Smilograss was tested by the University of California Agricultural Experiment Station as early as 1879 (Hanson, 1972). P. B. Kennedy started trials in 1914, and in 1917 received a letter from Mr. G. D. Stead of Spring Valley, San Diego County, suggesting that the grass was doing well and should be called smilo because "it makes the horses smile". It was certified in 1947 (Hanson, 1972).

Seed production has been erratic, but the seed stores well and was generally available in the 1950's and into the 1960's. However, it has not been commercially available for at least 10 years. There is a current demand for smilograss for both range and environmental seeding, and some users are collecting limited amounts of seed from old stands.

Smilograss is difficult to establish except in brush burns and on light soils. Seedling vigor is poor, and it cannot compete in a weedy seedbed. The difficulty of establishing smilograss stands on unburned soils and cultivated lands can be overcome by treating the seed prior to planting with sodium hypochlorite (household bleach) to improve rate of germination (Laude, 1951).

MISSION VELDTGRASS

Mission veldtgrass (Ehrharta calycina) is recommended for range and environmental seeding on sandy soils in coastal locations. Mission was developed by Dr. R. M. Love of the University of California at Davis from a nonshattering mutant received from Dr. R. C. Rossiter, CSIRO, University of Western Australia, in 1950. Its closed, compact panicles distinguish it from the old California veldtgrass. The nonshattering character was important in insuring economical seed harvest. Mission veldtgrass consistently yielded about four times the amount of seed of the earlier variety. Although Mission veldtgrass was released for certification in 1962 (Hanson, 1972), seed production has been limited and sporadic because of sporadic demand.

The early stands of veldtgrass have persisted and spread aggressively in sandy areas near the coast where it is considered a weed by native plant enthusiasts. Recent demands are more for soil stabilization purposes than grazing use.

ROLE OF MANAGEMENT

Range forage production, particularly that of perennial grasses, is limited more by management than by lack of potentially useful plants. Even if the extra forage produced is of sufficient volume to supplement the poor winter growth of annuals, the utilization must be very light to avoid reduced production and survival. Love (1972) stated "...little is known about the details of management placed on new varieties by the livestock operator who, incidentally, is not likely to be as concerned with intensive management as is the field crop or vegetable crop grower. Therefore, if an improved range forage cultivar is to be distributed to the livestock operator, it must be a greater than 100% improvement over the grasses it is to replace." This philosophy of range managers of recent decades has international support. Rogers and Lazenby (1966) said: "The approach to our work has been influenced by the fact that in the United Kingdom grassland management, rather than the grass variety, is the major factor limiting production."

In truth, then, failure of perennial grass seedings in California's annual grassland ecosystem has been the rule rather than the exception.

In California we may have been unrealistic in our expectations of the contribution perennial grasses could make to range improvement. Hardinggrass failures resulted from extremes in seasonal weather patterns, competition from annuals and a variety of other problems including changes in land use, improper management, and seeding outside its range of adaptation. Limited adaptation, lack of production, establishment problems, and poor economic climate are all reasons why perennial grasses are not widely used today.

From our perspective, seeding of perennials for range improvement in California is unlikely to be an important practice in the future. The economic situation facing ranchers and potential seed producers is not encouraging. Simple management practices that save money and do not require large financial investments will be the most attractive to land owners and managers.

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