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Past Performance and Future Potential of Black Grama for Southwestern Ranges[1]

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The possibilities of improving range and forage grass species for use in grassland farming is receiving renewed attention according to Beard (3)[2]. The need for range improvement in all aspects of grass improvement, brush and weed control, reseeding techniques, and management practices is generally accepted for the southwestern United States. Black grama, *Bouteloua eropoda* (Torr.) Torr., is one of the most important grasses of the arid and semiarid desert grassland. This paper is a review of the previous work on this grass to appraise its status, evaluate the factors limiting its use, and propose objectives necessary for improvement.

Descriptive Characteristics

Black grama is believed to be the most important forage grass on the 89 million acres of desert grasslands in Arizona, New Mexico, and parts of Texas, Oklahoma, Colorado, Utah, Nevada, and California (10). Black grama is a major species in Arizona and New Mexico, adjacent parts of Mexico, and possibly in southwestern Texas. The reviewers are of the opinion that it is of minor importance in the other areas of the Southwest. Hoover (42) presents a map showing the areas of major and minor distribution of black grama.

Black grama, a native grass, occurs abundantly over a wide altitudinal range and throughout the Southwest area and south into Mexico (19, 20, 40, 41, 45, 46, 47, 51, 52, 56, 57, 64, 77, 78, 81). It forms pure stands over wide areas of the region (29) and according to Humphrey (44), is dominant within the desert grassland which is sub-climax to a desert shrub climax (5). It is drouth tolerant both during seedling establishment, and as a mature plant, a quality indispensable to the establishment and maintenance of any of the major forage plants growing under prevailing arid and semiarid climatic conditions. It is palatable and nutritious, both in summer and winter, consequently it is particularly outstanding

FIGURE 1. Black grama-tobosa-yucca range in good condition in southwestern New Mexico. Black grama is a key species on many Southwestern ranges and was originally the mainstay of the range in many areas. The development of methods of increasing this grass on present ranges is an important objective of current research programs. *(Photo by R. R. Humphrey).*

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[2]*Numbers in parentheses refer to Literature Cited.*

as a year-round forage plant. Black grama, also referred to as wooly-foot or crow-foot grama (10, 36) is a tufted, branching, strong-rooted, long-lived perennial grass. It is readily recognized by the wiry, wooly-pubescent, usually geniculate and spreading culms (30). The creeping runners or stolons, which root at the joints and send up new shoots that later become separate plants, make the grass valuable for soil protection (10, 25). Technical classifications and descriptions of black grama have been presented by several workers (30, 35, 41). A practical description is presented by Humphrey, Brown and Everson (47).

Black Grama Range Research History

The need for range studies and experimentation was recognized at an early date. Shear (68) presents a review and summary of the work of investigating the various problems relating to the grasses and forage plants of the United States by the Department of Agriculture, Division of Agrostology, from the time of its organization in 1895 to 1901. He states that the southwestern region presents difficult conditions and problems and that *Bouteloua eriopoda,* "wooly-foot grama," is one of the most valuable range grasses in the region.

In 1900 an area of mesa land near Tucson was set aside by presidential proclamation for experimental range studies (31). This small range reserve was a cooperative project of the U. S. Department of Agriculture and the University of Arizona Agricultural Experiment Station. In 1902 the Santa Rita Range Reserve near Tucson was set aside by presidential proclamation (71). The Jornada Experimental Range near Las Cruces, New Mexico, was established by executive order in 1912. The Bureau of Plant Industry operated these ranges until 1915 when the administration of both ranges was shifted to the Research Branch of the U. S. Forest Service. Presently, the Santa Rita Range Reserve is used by the Forest Service, the Agricultural Research Service, and is available to the University of Arizona Agricultural Experiment Station. The Jornada Range Reserve is administered by the Agricultural Research Service. Previous work with black grama has been largely conducted at these experimental range reserves, where black grama is a major species of the native grass composition.

The U. S. Soil Conservation Service set up an evaluation program including the establishment of plant nurseries in Arizona and New Mexico in 1934. The primary purpose of this program was to study revegetation of rangelands in respect to soil and water conservation and flood control, with black grama being one of the species receiving attention for these uses. Operation of the Arizona Soil Conservation Service Nursery was delegated to the University of Arizona Agricultural Experiment Station in 1953, and at the same time the New Mexico Nursery at Albuquerque was disbanded.

Literature Review

The literature reveals that black grama has been under observation for many years. Most of the work on this grass has been concerned with facts pertaining directly to or associated with management. There have been few basic studies pertaining to the fundamental aspects of growth and reproduction. A selected bibliography on management of western ranges, livestock, and wildlife has been compiled (65) which includes the published work on black grama to that date.

Management

Griffiths (31) and Thornber (71) concluded that the poor condition of the Southwestern grama grass ranges at the time, near the turn of the century, had been brought about by overstocking.

In 1916 Wooton (80) presented the results of several years' work on black grama originally started by others (32, 33, 35). The author concludes that with complete protection from grazing the range recovered rapidly at first, with large gains being made in the first two or three years, and that complete recovery was reached in approximately 10 to 12 years. He points out that even light stocking resulted in doubling the time required for complete recovery as compared to completely protected areas.

A study reported by Jardine and Forsling (49) showed that on predominantly black grama ranges, drouth alone, if prolonged beyond the second year, killed 40 percent of the black grama plants and reduced the quantity of forage produced by the remaining plants by approximately 50 percent. Grazing tends to increase the effect of drouth; however, the authors (49) suggest that desired results may be obtained by reduction of stocking to 85 percent of the original carrying capacity the first year, to 60 percent the second, and to 50 percent the third. The ill effects of drouth on black grama are presented by Canfield (14) for a 21-year period. He found ample indication that a part of the forage produced in the more bountiful seasons could be carried over and used to supplement the less productive years. The ungrazed stems of black grama remain green for two or more seasons, making it, unlike its associates, a natural source of reserve feed. Canfield (16) later states that semi-deferred grazing provides for recovery after misuse, protection against drouth, utilization of the seasonally palatable forage, and a more stable carrying capacity.

Nelson (55) reports a 13-year study of the influence of precip-

itation and grazing upon black grama grass range and concludes that the test emphasized the ability of black grama to survive two drouth periods (1916-18, 1921-26). Ordinarily one favorable growing season appeared necessary to restore the vigor of weakened plants before marked improvement in the stand began. Black grama was found to compete successfully with associated species after depletion of stand by drouth, and to withstand conservative utilization by livestock, while heavy grazing resulted in gradual or extreme deterioration.

A summary of the records of studies of the effects of climate and grazing on black grama under three grazing intensities, conservative, moderate, and heavy, and on protected plots for the period 1916-56 are reported by Paulsen (62). He emphasizes the following points: a. the precipitation shows no general longtime upward or downward trend; b. at approximately 20-year intervals, rainfall was alternately about 10 percent above and below average; c. irrespective of the degree of grazing use, density was reduced to about the same point during extended drouths; d. density during years of more abundant rainfall is greatest on areas conservatively grazed; and e. the rate of recovery after drouth depends on the stand that remains to revegetate the area at the end of the drouth.

The most beneficial precipitation distribution for both density change and height growth consists of relatively dry winters between relatively wet autumns and springs (50). According to McGinnies and Arnold (51) the desert grassland group of grasses, including black grama, are very similar as to their water requirements.

It has been proposed (11) that types of stem structure reflect the moisture requirements and periods of growth of grasses. The *Bouteloua* species have solid stems, a characteristic that aids these species in surviving arid and semiarid conditions. Canfield (11) further concludes that this stem character is a criterion which may be employed in the selection of grasses for introduction into the Southwest.

Campbell (8) and Campbell and Crafts (10) state that proper utilization of black grama is essential to good growth and spreading, which means utilization of about 50 percent of the total growth on a weight basis or 70-85 percent of the height growth. He concludes that black grama should not be grazed until summer growth is complete if other areas are available for grazing. Making use of the winter and spring palatability of black grama encourages spread and promotes the use of other species palatable only when green (8, 10). The aim should be to graze moderately in good years and to reduce grazing in poor years in relation to production.

Campbell and Bomberger (9) conclude that at least two inches of stubble and 15 percent of the flower stalks must be left on the ground each year if a reasonably good stand is to be maintained. A 25 to 30 percent reserve left ungrazed at the beginning of the new growing season is recommended by Canfield (12). As a result of further studies, Canfield (14, 17) suggests a 15 to 25 percent balance of ungrazed forage at the close of the growing season as the best insurance against range deterioration and livestock losses due to drouth. He suggests that stocking on a sustained yield basis materially increases herd earnings and that a 20 percent reserve of forage is advisable as insurance against drouth. Culley (22) concludes that black grama should not be grazed closer than to within three inches of ground level. The differences of percentage of optimum ungrazed forage suggested by the various authors may be accounted for by variation of seasonal climatic conditions. Perhaps 25 percent of the forage produced may be the optimum reserve. An economic study by Culley (21) shows the yearround carrying capacity of predominantly black grama ranges varies from one cow to 23 acres to one cow to 60 acres. The results of clipping experiments on semidesert black grama range have been presented by Canfield (15). He concludes that persistent clippings of all herbage to a height of 2 inches or less ultimately results in critical deterioration through excessive wind and water erosion. The need for balanced livestock and forage production is presented by Darrow (24).

Canfield (12) reports on the desirability of semi-deferred grazing. He states that semi-deferred grazing by light stocking during the summer grazing season and heavier stocking during autumn, winter and spring months provided for yearlong use, and gave satisfactory results on extensive areas of black grama range. The effects of thirty years protection from grazing of mixed gramas and other species have been presented by Gardner (27). Little difference in species was noted between protected and unprotected areas although grass density on the protected area was 110 percent higher than on the unprotected areas.

A guide for measuring utilization of black grama and other range grasses is proposed by Pearse (63) using the percentage of grass plants that are ungrazed as a key to measurement of utilization. Valentine (72) proposes a modified scaling method for determining utilization of range grass plants, where the original observations are in percentage of weight removed instead of using a linear scale and converting to

weight basis. Several methods of establishing proper utilization of important forage species are discussed by Campbell (7). He states that regardless of the method of determining utilization, the figure obtained on a range must be compared with a predetermined proper utilization percentage for the important forage species. Also very careful observation of soil erosion, disturbance, and range condition are necessary for an adequate picture of utilization and its effects on the range.

Measuring utilization of range grasses including black grama by use of clipped quadrats is discussed by Culley, Campbell, and Canfield (23). The authors conclude that the method fails to completely simulate grazing by livestock, yet valuable indications may be obtained as to what constitutes proper utilization.

Reynolds and Bohning (67) report that black grama density was seriously affected by June burning, and it did not recover during the period of the study (1952-1954). The effects of mesquite density on the density of associated black grama are reported by Parker and Martin (60). On untreated areas for an eight-year period, grass density gradually decreased to a negligible percent, while the best herbage yields were obtained when mesquite alone was killed. Paulsen (61) found that soil physical properties were more favorable under black grama cover than under mesquite bushes. The soil under mesquite bushes was coarser, had a lower pore volume, was less favorable in respect to moisture relations for plant growth, and was more unstable.

Nutrition

Watkins (75) presents a review of literature dealing with the nutritive value of range forage grasses and concludes that it is known to vary widely. He states that these variations are due to a number of factors, such as species, stage of maturity, seasonal changes, fertility of the soil, elevation, moisture content, weathering and leaching, distribution of rainfall, and temperature. According to Stanley (70) there is a decline in protein, calcium, phosphorus, and carotene during the winter periods in Arizona range grasses including black grama.

A study by Watkins (73) shows phosphorus and calcium highest during the growing season, with approximately 75 percent of the phosphorus and 25 percent of the calcium lost during the winter months for many grass species analyzed. The analyses, which included black grama, indicate a greater deficiency of phosphorus than calcium in the range grasses of New Mexico. A later study by Watkins (74) showed that carotene content of black grama is moderately high during the growing season with sufficient carotene to satisfy the vitamin "A" requirements of range cattle. Watkins (75) concludes that the easily digested carbohydrate does not decrease and is not lost in the wintering and leaching process, making black grama a valuable roughage. Protein content was found to be high during the growing season. An average loss of 37 percent protein was found between October and March. Watkins (75, 76) further found that the phosphorus content was not sufficient to meet the requirements of cattle except for a short period at the peak of the growing season, while carotene levels were sufficient for beef cows even during the gestation and lactation periods. Watkins (75) indicates there is a relationship between available soil phosphates and the phosphorus of the forage. He suggests (75) that the quantity of amido protein present is a measure of wintertime plant activity.

Moderately high protein values for black grama are usually found during the winter, due largely to the light precipitation during the season (76). An early report (36) also shows the desirable nutritional qualities of black grama.

Cytology and Growth Behavior

Fults (26) reported 2n=21 while investigating three different seed sources of *Bouteloua eriopoda*. He reports many aneuploid chromosome numbers in this genus. According to Brown (6) the basic number of chromosomes x=7 was found for six species; (*Bouteloua chondrisioides*, 2n=24), (*B. eriopoda*, 2n=28), (*B. filiformis*, 2n=14), (*B. regidiseta*, 2n=28), (*B. trifida*, 2n=28) and (*B. breviseta*, 2n=28). He reports that these studies do not confirm the conclusions of Fults that the species of *Bouteloua* are largely aneuploid. Both authors point out that since relatively few plants have been studied, variation in chromosome numbers may be found by further search. Recent investigations indicate that the basic chromosome number is 10, rather than the previously reported 7 for the *Bouteloua* genera, although some forms with x=7 have been demonstrated (38, 39). Fults (26) states that the length of chromosome ranged from 0.25 to 1.50 microns with an average length of 1.00 micron, and there appeared in each complement two small spherical chromosomes which appeared to be characteristic.

From his studies Fults (26) concluded that the Southwest is near the center of distribution of the genus *Bouteloua* due to the predominance of low chromosome numbers coupled with the fact that the species are often dominant. Myers (54) points out the possibility of apomixis in some *Bouteloua* species due to the common occurrence of aneuploid numbers.

Growth and flowering responses as affected by photoper-

iod for several of the species of *Bouteloua* have been reported by Olmsted (58, 59). He states that black grama should be regarded as a short day plant as defined by Allard and Garner (1). It was found (58, 59) that the total number of tillers, tillers bearing inflorescences, and crown roots were inversely correlated with length of photoperiod; while average maximum height, average dry weights of roots and tops, and vigor of individual inflorescences were correlated positively with length of photoperiod. He states that experiments have indicated that winter chilling is unnecessary to bring about reproductive activity. According to Olmsted (58) the photoperiodic responses of black grama should be investigated in greater detail.

FIGURE 2. Black grama research plots at Tucson, Arizona. Studies are being conducted here to determine the factors affecting seed set. The seed habits of this grass are extremely variable, and the seed crop produced by native stands generally has low viability.

Reseeding

There are many range reseeding techniques and problems (2). Black grama has been little used for reseeding because supplies of good seed have been scarce and are not commercially produced due to poor seed production qualities (2, 25, 28, 42, 55, 69, 79). Campbell (8) points out that reseeding costs are high because seed is obtainable only from native stands where seed production is characteristically poor. Jackson (48) in studies with native seed obtained 0 percent germination, and an examination of the material revealed that there were no caryopses present, which emphasizes the poor seed producing capabilities of black grama. Black grama is slow to become established; however, plantings made on very dry sites have persisted through several drouth years (2).

Bridges (4) points out from his studies that failure to produce stands in the field is not due to lack of seed viability but to the lack of proper conditions for germination. Wilson (79) reports an average percentage of germination of 3.72 for two lots of 100 seed, each tested in duplicate and retested. Germination of 22 percent and purity of 37 percent have been reported (82) along with an intermediate seed longevity classification. Hulling or processing seed improves purity to 90 percent and germination to 65 percent (82). These varying results might indicate that laboratory germination procedures warrant further investigation.

Flory and Marshall (25) state that black grama seed cannot be separated readily from the straw, resulting in variability in quality. Although there are about 1,300,000 seeds in a pound, a pound of average quality bulk planting material may contain as few as 100,000 pure live seeds. A figure of 1,335,000 seeds per pound along with values of 300,000 seeds per pound when cleaned, and 500,000 as hulled or further cleaned have been reported (82).

Due to the generally arid conditions in black grama areas, planting in contour furrows or in connection with other water spreading, water concentrating, or water saving structures is a prerequisite for successful establishment (2, 25). About 12 pounds per acre of average bulk planting material is suggested (25), and a rate of 10-15 pounds per acre of unspecified quality has been proposed (82).

The transplanting of clumps of black grama as a means of revegetation of ranges is proposed by Glendening (28). He states that success can be achieved if a few simple rules are followed. Transplanting of clumps yields best results when done during July or August, when soil temperatures are reasonably high and the soil is well moistened to a depth of at least six inches. The use of the transplanting technique is also discussed but not recommended by Goodding (29) and Wilson (79). Both authors state transplanting is not practical for range improvement.

One of the difficulties of artificial range reseeding is pointed out by Reynolds (66). Rodents can cause damage; however, Reynolds (66) suggests that seed as small or smaller than black grama are not likely to be discovered and dug out. He further concludes that low perennial grass densities are associated with high kangaroo rat densities.

Status

Black grama possesses many desirable characteristics, making it an outstanding range grass of the arid and semiarid grasslands of southwestern United States. Black grama is a well adapted native, long-lived perennial. It can be maintained on the range. Although it is not as abundant as in previous years, its spread can be slowly accomplished by proper utilization and management practices. Black grama's soil protection qualities are most desirable due to the ability of the stem joints to take root, resulting in new plants, making not only a valuable soil protector but providing a means for spreading and revegetation. The drouth tolerance of this grass is exceptional in that this characteristic is effectively demonstrated through all growth stages; however, continued use and drouth can seriously deplete stands. It is a dependable forage plant with the ability to perform well under grazing. The literature indicates highest yield performance and persistence when deferred grazing is used, as compared to nonuse or heavy grazing.

The grass is characteristically nutritious at all times of the year, and in comparison with other forage species, the winter and spring nutritional values make black grama outstanding. It is a palatable forage and highly relished throughout the year, and is of particular importance during the dry spring period when other range species are harsh and parched. Unlike most of its associates, black grama is a natural source of reserve feed, since the ungrazed stems remain green for two or more seasons. This feature, coupled with management, minimizes drouth hazard and provides a more stable carrying capacity.

Evaluation and Objectives

This review indicates that many of the principles of black grama range management have been studied and that there has been a minimum of research on the more basic aspects of growth and reproduction. An evaluation of this information indicates that the one characteristic limiting the widespread use of this grass for range reseeding is its extremely poor and unreliable seed setting capabilities. Obviously, the key to its widespread use for reseeding hinges on the improvement of seed production.

In this instance the aim of the plant breeder should be to maintain the many desirable characters while improving seed production (37). Once the factor or factors limiting seed set can be determined, research will be needed on the cultural techniques necessary to produce seed in sufficient quantity for an economic product.

There is need for further investigation of the physiology, cytology, mode of reproduction, breeding behavior, and cultural practices of this grass in order to utilize the most advantageous breeding procedures.

There are no recorded data on the use of fertilizer in relation to reseeding or the effect on yield and nutritive value of black grama. Seed quality factors such as purity, germination, and longevity, reseeding practices, management techniques, and seed processing problems should be considered following the improvement of seed setting along with the development of breeding procedures. The elimination of seed production barriers, which at present are limiting, along with methods of establishing stands in hot, dry areas would allow black grama to take a prominent role in revegetation of the desert grasslands of the southwestern United States.

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