MANAGEMENT OF BERMUDAGRASS FOR SEED PRODUCTION IN OKLAHOMA

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Contents

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Management of Bermudagrass for Seed Production in Oklahoma[1]

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Introduction

The genus *Cynodon* L. C. Rich, tribe Chlorideae is comprised of nine species and ten varieties (Harlan et al., 1970). The only member of the genus with world-wide distribution is *C. dactylon* var. *dactylon*. It is a sod-forming, warm-season perennial grass that is extremely variable, ranging from very small, turfy types to robust forage types.

Bermudagrass, *C. dactylon* (L.) Pers., is grown for pasture, turf, and soil stabilization throughout the southern half of the United States. Improved forage cultivars such as 'Coastal' (Burton, 1948), 'Midland' (Harlan et al., 1954), 'Greenfield' (Elder, 1955), 'Hardie' (Taliaferro and Richardson, 1980), 'Tifton-44' (Burton and Monson, 1978), and several cultivars for lawns, playgrounds, and golf course greens and fairways have played a major role in the acceptance and popularity of the species. The Midland and Coastal cultivars have at least twice the forage yield potential of most unimproved "common" types of bermudagrass. These two cultivars are now planted on an estimated 20 million acres across the southern United States.

Most bermudagrass cultivars produce few or no seed and must be propagated vegetatively. This greatly limits the versatility of bermudagrass because establishment technology (equipment) cannot be used efficiently in confined areas such as home sites, or on steep embankments such as dam faces or roadbanks. To our knowledge, only two bermudagrass cultivars are presently commercially propagated by seed. One is "Arizona Common", a tetraploid strain of common bermudagrass grown for seed along the Colorado river in southwestern Arizona and southeastern California. The second type is a diploid form belonging to the taxon *C. dactylon* var. *aridus*, commonly called "giant" bermudagrass. 'NK-37' is a commercial cultivar of this type. Seed production of the giant type is also confined to Arizona and California.

Both the common and giant bermudagrass types are relatively non-winterhardy and susceptible to diseases (Wells and McGill, 1959). Development of more winterhardy, seed-propagated cultivars should greatly expand the geographic range where bermudagrass cultivars can be reliably used.

Several research studies (Ahring et al., 1974, 1975, 1978; Burton and Hart, 1967) have shown that *C. dactylon* germplasm is available which should enable the development of seed-propagated cultivars having higher levels of cold tolerance and pest resistance. From a world-wide collection, we identified individual plants which have

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good fertility and high seed production under Oklahoma conditions. These plants have routinely been highly self-incompatible, but they are cross-compatible with most unrelated plants. Single-cross plant populations, from seed produced (Ahring et al., 1975) by interplanting pairs of such clones in isolation, showed a distinct superiority in winter survival over Arizona common. However, in addition to being winterhardy, the criteria which a seeded bermudagrass must fulfill to be successful are: 1) easy establishment 2) disease resistance, 3) produce reasonably high forage yields or have a sod density suitable for lawn and recreational use, and 4) have good seed production characteristics so that commercial seed supplies can be maintained.

There has been little research aimed at characterizing the effects of cultural and management practices on bermudagrass seed production. Understanding the influence of these practices on seed yield is fundamental to establishing efficient seed production systems. This bulletin summarizes research findings on the effects of nitrogen fertilization, and early season forage removal practices on the production of bermudagrass seed in Oklahoma.

Description

Four Oklahoma Agricultural Experiment Station bermudagrass clonal accessions, A-9945 (P.I. 206427), A-9959 (P.I. 253302), A-10978-b, and A-12156 were the plant materials used in the studies. The origins of these accessions were Yugoslavia (A-9959), Turkey (A-9945), Israel (A-10978-b) and Oklahoma (A-12156, a hardy common type collected near the town of Guymon, Okla.). They were selected for their winterhardiness and seed production potential based on preliminary investigations (Ahring et al., 1974; Richardson et al., 1978). Each clone is essentially self-sterile, i.e., each sets very little seed when grown alone, but has the potential for excellent seed-set when grown in combination. Two of these clonal accessions (A-9959 and A-12156) are the parents of the cultivar ''Guymon'' recently released by the Oklahoma Agricultural Experiment Station and the Agricultural Research Service, U.S. Dept. of Agriculture.

Establishment of Seed Production Fields

Bermudagrass for seed production is best on medium- to heavy-textured fertile soils with soil pH values of 6.5 to 8.0. The two parental clones of the Guymon cultivar must be sprigged in a manner to facilitate cross-pollination to produce Foundation seed. Each clone combination should be sprigged at an approximately equal rate of roots (sprigs) at a depth of 2 to 3 inches (5 to 7 cm) in alternating rows spaced 3 to 9 feet (1 to 3 m) apart. The amount of sprigs required to establish a hectare depends on row spacing used and may vary from 15 to 40 bushels. Fields can be sprigged from March 15 through June 15.

Seed production fields, whether established from seed or sprigs, require good weed control and fertilization programs. Seed fields should be fertilized with phosphorus and potassium according to soil test recommendations prior to planting. Nitrogen fertilization of 30 to 60 pounds N/acre (34 to 67 kg N/ha) should be applied after the sprigs germinate and begin to spread.

Weed Control

Good weed control during the establishment year is essential. Broadleaf weeds and weedy grass problems in sprigged fields can be avoided by the proper use of pre- and post-emergence herbicides. Pre-emergence herbicides such as diuron (Karmex), simazine (Princep) and atrazine (Aatrex 4L) if applied immediately after sprigging according to label instructions will control most weeds through the spring and summer months. Limited use should be made of these herbicides because of the physiological effects (especially diuron and atrazine) they have on plant growth. Seed yields may likewise be affected.

Broadleaf weeds can be controlled any time after sprigging with 0.5 to 1.0 pounds 2,4-D ai/acre. For perennial weeds, spot-spray applications with glyphosate (Roundup) will provide adequate control. In addition to Roundup, "Oust", a new product released by Dupont Chemical Corp., does an excellent job of controlling Johnsongrass in spot-spraying applications. Weed control after establishment is usually a minor problem for 3 to 5 years, provided a well-established field cover is obtained the year of establishment.

Seed Production

General Climatic Requirements

Areas in Oklahoma with long-term average annual precipitation of 24 to 32.2 inches (60 to 82 cm), with a marked seasonality in distribution of about 5.5, 4.0, and 3.5 inches of the total occurring in May, June, and July, respectively, are well suited for bermudagrass seed production under dryland conditions. Areas and years not having this minimal distribution pattern are high risks for good seed production under dryland conditions and should have irrigation capability available to complement existing rainfall.

Daytime temperatures of 86 to 100 F (30 to 38 C) and intermittent rainfall patterns are near optimum for bermudagrass seed production. However, severe temperatures 100° + F for an extended number of days, as well as too much rainfall during May, June, and July, can be detrimental to seed production. Seed yields should be profitable under supplementally irrigated and dryland conditions in central Oklahoma and under only supplementally irrigated situations in the western parts of Oklahoma.

Water Management

Bermudagrass seed production differs from certain other grasses in that plant competition for light, nutrients, and moisture is uniformly distributed and yield is more dependent on water management for a particular cultural practice. The value and utilization of nitrogen fertilization depends on water management and the distribution of rainfall. Alternate wet and dry cycles are needed in the production of bermudagrass seed to first promote, and then to slightly stress plant growth. These alternate wet-dry cycles stimulate seedstalk production and flowering. Three or four such growth-stress cycles during May, June, and July are needed to produce an accumulated seedstalk (head) mass, good seed set, and a good seed crop in August.

Our observations on the amounts and distribution of natural rainfall and supplemental irrigations suggest that: 1) too much moisture results in reduced seedstalk production, thus reduced yield, 2) less rainfall, adequate N-fertilization (60 lbs/acre or 67 kg N/ha), and timely irrigations, especially during June and July, result in the highest number of seedstalks produced, and 3) rainfall in excess of the crop's needs results in heavy forage growth and improper timing of growth-stress cycles. The full benefit of alternate growth-stress cycles, manipulated by timing of irrigations, has appeared optimum for seedstalk production in the *drier* years. The production of seedstalks may be decreased by untimely rainfall. Thus, instead of 3 to 4 flushes of seedstalks during the growing season, only two may contribute to yield. The more the number of seedstalk flushes, the greater the number of seedstalks (heads) to contribute to total yield.

Nitrogen Fertilization

Provided all other essential nutrients are in good supply, nitrogen fertilization is the most important cultural practice in the production of bermudagrass seed. In our studies the optimum rate of nitrogen on a heavy, slightly alkaline (7.4 pH) soil has been 60 lb N/A (67 kg N/ha). However, seed yields were excellent at all N levels studied, 30 to 100 lbs N/A. Fertilization and water management effects on the accumulative (number) seedstalks produced per unit area per season depends primarily on timing and amounts received or applied.

Two management systems and their response to nitrogen fertilization have been studied. Management "A", removal of spring and summer vegetative growth on May 1, and management "B", two forage cuts, one on May 1 and the other three weeks later, were compared in 1975, 1976, and 1977. Although seed yields as influenced by N-level were not significant, the highest yields for management A were attained at the 30 lbs N/A (34 kg/ha) rate in 1976 and 1977. Where two forage removals were made prior to allowing the field to mature a seed crop, yields were highest at the heavier rates of 60 and 90 lbs/A (67 and 101 kg/ha) in two of the three years.

Management Effects

In all three years of the study management "A" had the highest seed yields, Figure 1. The significant year and management effects, and the significant management by year interaction suggest that management practices are more essential than are cultural (nitrogen) for the production of high seed yields, Figure 2. Similarly, in all years of study the highest average number of seedstalks was produced following the forage removal (cut-back) date of May 1. Two cut-backs, management "B", in general reduced the number of seedstalks that contribute to seed yield. Seedstalk production is evidently a function of time and growth-stress sequence that is shortened under management B. Seedstalk production is a major component of yield and is dependent on fertility and management practices. The final determinates of yield are number of florets per raceme and number of florets to set seed (seed-set).

Seed-Set

Seed heads from plots receiving the management A treatment contained as many as seven florets per raceme (3-year average) more than those in plots receiving two cut-backs (B). Nitrogen, although not significant, has a greater effect on percent seed-set

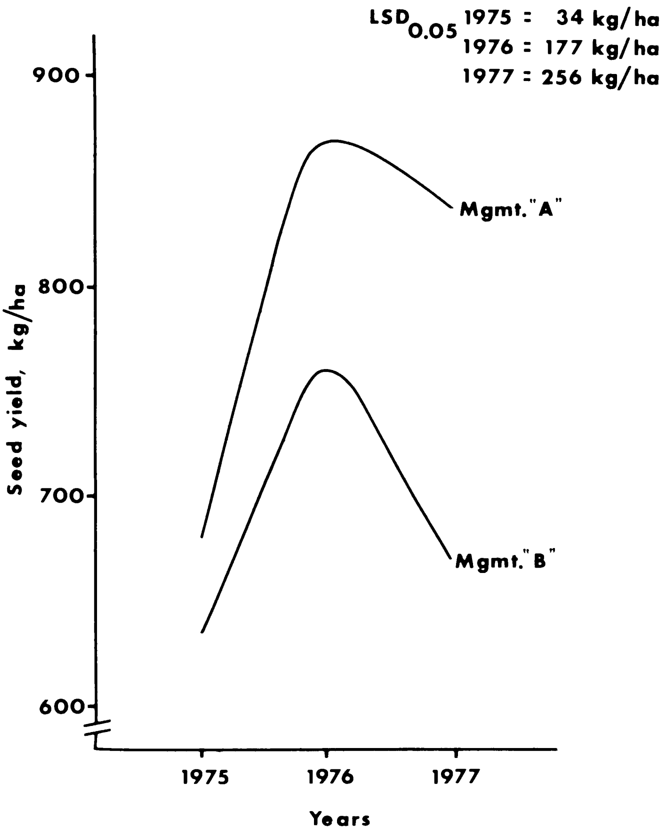

Figure 1. Mean seed yields for years by management practices (Mgt. "A" forage removed on May 1 and then fertilized and "B" forage removed twice on May 1 then fertilized and again removed on May 21).

than management. Seed-set varied as much as 13 percent between years for both management levels. Without exception, seed-set percentages were highest at either the 60 or 90 lbs/A N rates. Although little attention has been given to the effect of pollination and compatibility of pollen on seed-set in grasses, the efficiency of the flowering process to a large extent determines seed yield. In several strains and hybrids of bermudagrass (Richardson et al., 1978), seed-set was found to range from 0.0 to 78 percent. In most perennial grasses seed-set seldom exceeds 70 percent (Ryle, 1968). Throughout our studies involving several locations, seed-set has ranged from 54 to 79 percent and is considered well within the range for high seed yields, if other components of yield are good.

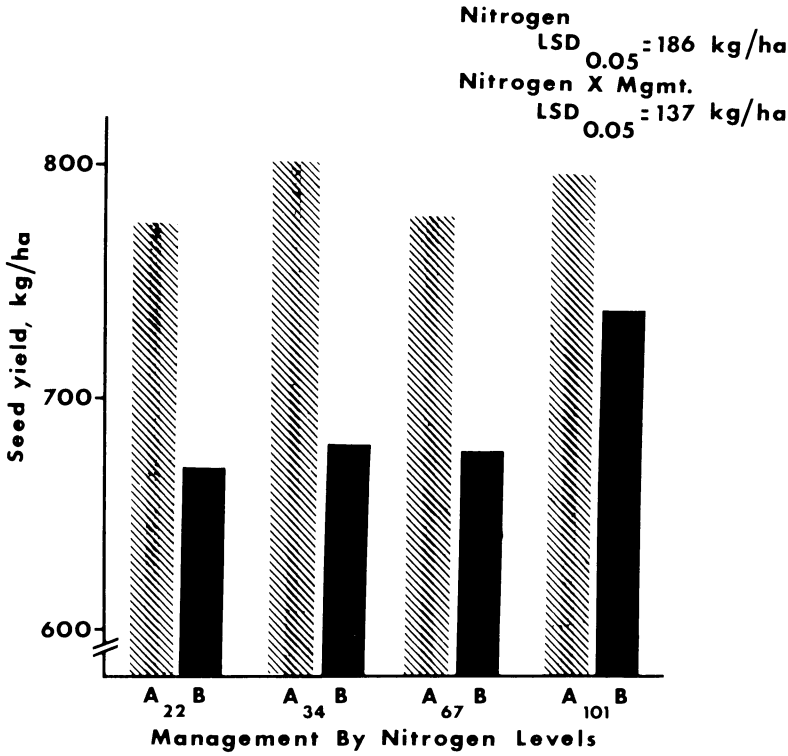

Figure 2. Mean seed yields averaged over years by nitrogen-levels and management practices, A and B.

Harvesting Bermudagrass Seed

A major problem in producing certain grass seed is that of seed harvesting. Heading and flowering of many range and pasture grasses take place over a long period. Some grasses, after reaching a certain physiological stage, produce seedheads continuously for periods of one to three months during the growing season. As a result, at harvest some seedheads are ripe, early heads have shattered, and later heads are immature (Ahring et al., 1978). Judgement, and a certain degree of guesswork, is involved in selecting optimum harvest dates in these species, and accounts for a large part of the amount of treatment and year to year variability in studies dealing with such species.

Grass seed retention, or shatter resistance, on the inflorescense appears to be genetically controlled (Bonin and Goplin, 1963; Griffiths et al., 1966; McWilliam, 1963). Some grass species, however, shatter readily soon after reaching physiological maturity, e.g., Kleingrass, *Panicum coloratum* (Boonman, 1973); others retain seed for long periods after maturity. *Bermudagrass falls in this latter category. This characteristic is one of the reasons high seed yields are possible, with proper management.* However, bermudagrass is a reasonably low-growing sod-forming species, and one must handle the vegetative growth to remove the seed in the harvesting operation.

Swath-Cured and Combine Harvesting

Seed fields of bermudagrass are normally swathed and allowed to cure for several days before combining. After the initial threshing, the tailings are rethreshed three or four times in order to obtain as much of the seed as possible. This harvesting technique is a time and energy consuming process and therefore an expensive operation.

In our search for a grower efficient harvesting technique, we found large differences in amounts of seed harvested on a first-thresh basis, as shown in Figure 3. The conventional method, swath-cured then combined, harvested 31.2 percent of the seed crop. If a higher percentage of the crop could be harvested during first-thresh, it would lessen the time required in harvesting and reduce energy, labor, and equipment repair costs without reducing yields.

Chemical Desiccation and Direct Harvesting

We found that 14 to 26 percent more seed can be harvested following chemical desiccation of the crop canopy with 'paraquat' (1,1'-dimethyl-4,4'-bipyridinium ion). The highest percentage harvested was obtained using a seed stripper (an Australian plot harvester) following desiccation. This unit is not made commercially in the United States, nor is it large enough for grower use. However, it could easily be built on a larger scale in many well-equipped farm shops. After this initial crop harvest (stripped), the field is combined direct and tailings rethreshed once or twice.

For grower use, the chemical-cure and combined direct method appears to have advantages over the conventional harvest method in that: 1) it requires no initial swathing operation, 2) it requires less time to cure, 3) it increases harvesting efficiency, and 4) it reduces the number of rethresh tailing operations needed.

Although it is not shown, harvestibility of paraquat-treated plots (0.5 kg/ha) was far superior to dinoseb. This is not to say that other compounds, e.g., urea-ammonium nitrate (UAN) spray solutions (Donnelly et al., 1978), may not be as good. In fact, if UAN solutions work, the grower would cure his crop for havest and fertilize for the fall crop in one operation. The use of paraquat has several disadvantages (Ahring and Stritzke, 1982): 1) there is a potential applicator health hazard; 2) residual tailings cannot be fed to livestock; 3) decomposition of field litter seems to be retarded, and field regrowth and recovery following irrigation is slowed; and 4) evidence suggests that seed quality of the unhulled seeds harvested may be affected.

Combine Setting

When combining the seed crop, regardless of pre-harvest curing methods employed, combine setting is critical. The grower should adjust the forward speed of the combine with the width of the platform or swath so that the machine is kept evenly loaded. Adjust cylinder speed to about 1300 rpm for small combines having 15-inch cylinders and to about 1100 rpm for combines having 18-inch cylinders. Set the cylinder-concave gap so close at first that it clatters, then back off just a fraction, approximately 1/8 to 1/16

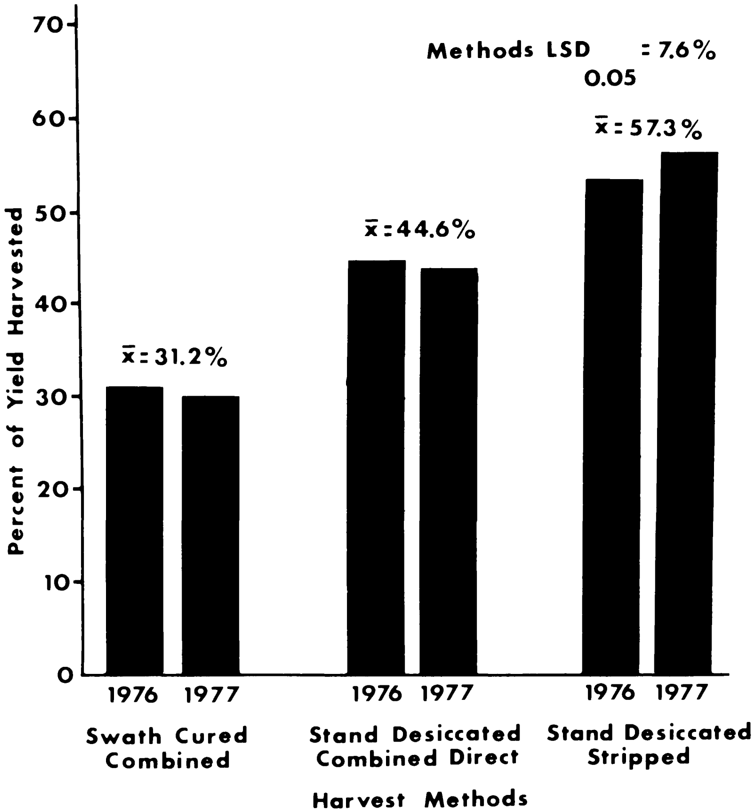

Figure 3. Average bermudagrass seed yields in percentage seed harvested in a once-over or first-thresh basis. Yields harvested from a 0.9 x 6.1 m (3 x 10 ft.) area by removing at near ground level, all forage and seed, allowing it to cure, then hammermilling and removing the threshed seed in a cleaning operation was used as the standard for comparing harvest percentages.

apart. Cut off air from the cleaning fan completely by stopping the blower or slowing to its slowest speed; cover all openings with cardboard or other suitable material and tape. When threshing swathed material, a mounted pickup attachment on the platform is desirable but not a necessity. If the reel is left on, set the platform on the ground and adjust reel height to swath and reel rpm for feed-rate. Rethreshing the combine tailings is essential to obtain maximum yield. The number of tailing rethreshes needed can be determined by checking the seed delivered to the grain bin or box.

Seed Quality

Effect of Chemical Desiccation

The use of paraquat (Ahring and Stritzke, 1982) as a bermudagrass desiccant prior to seed harvest may have some drawbacks. Significant differences in seed germinability have been found between seed harvested after exposure to pre-harvest desiccation with paraquat versus no spray prior to harvest. The effect was significant if the seed harvested from treated plots remained unhulled. Removal of the subtending appendages (hulling) and germination on water and/or a 0.2% KNO_3 moistened substrate significantly improved germination. Mechanical scarification of hulled seeds removes all apparent paraquat effect. The appendages evidently intercept the paraquat and protect the caryopsis. However, the number of abnormal seedlings associated with the germination of seed over-sprayed with paraquat suggests that paraquat does affect seed quality.

Germination Procedure

Using a 0.2 percent KNO_3 solution as a moistening agent, as recommended by the "Association of Official Seed Analysist Rules for Testing Seeds", improves germination over water substrate. Unhulled, hulled, and scarified seeds germinate better when KNO_3 is used in the testing procedure. However, germination of unhulled seed from paraquat-sprayed plots is significantly lower than that of seed lots receiving no paraquat.

Although hulled and hulled-scarified seed harvested from paraquat-treated plots germinate as well as the same seed forms from unsprayed plots, a significant reduction occurs in germination of unhulled seeds. This is evidence that paraquat may drastically affect the planting quality of the seed produced.

Seed Production

Economical yields from stands established from F_1 seed would eliminate the necessity of growers having to sprig their production blocks to cross compatible clones. Tests at two locations in Oklahoma showed that: 1) winterhardy stands are easily established with seed produced from the original cross compatible paired clones; 2) plants produced from the F_1 seed are highly heterogenous (highly variable plant types); 3) plants produce less forage than our better forage bermudagrass cultivars; and 4) seed yields harvested from F_1-blocks are lower than that of the original parent cross. However, seed production of F_1 plants were not compared to parental plants in replicated tests. Yield averages varied from 80 to 190 lbs seed/acre (90 to 210 kg seed/ha) for the Syn-1 seed lots as compared to 446 to 802 lbs seed/acre (500 to 900 kg seed/ha) from the original cross-compatible strains.

Seed produced from foundation 'Guymon' fields can be used to establish certified seed production fields. Seeding dates depend on whether unhulled or hulled seeds are used in planting. For quick and uniform emergence, hulled seed should be used but planted when the soil temperature has reached at least 65°F (17 C). Plantings can be made anytime up to July 15 without danger of winter-kill the following spring. Unhulled seed can be planted as early as February.

Seeding Rate

Seeding rates needed to establish fields are dependent on row spacing. A pound (454g) of hulled bermudagrass seed contains between 1,396,780 to 2,099,251 seeds. A pound of unhulled seed contains between 996,793 to 1,291,115 seeds. On a 12-inch (30 cm) row spacing a seeding rate of 2 to 3 pounds (1.0 to 1.25 kg)/acre of hulled and 2 to 4 pounds (1.0 to 1.8 kg)/acre of unhulled seeds are needed. However, growers can use wider row spacings (36 to 40 inches) and still get a complete cover before frost if weeds are controlled and growing conditions are good. A wider row spacing of 36 to 40 inches requires a minimum of only about a pound of seed to an acre.

A clean, firm seedbed is necessary in obtaining a good seedling stand. Seed should be planted very shallow (0.5 cm) and the row firmly packed with a press wheel behind the planter. Grass drills e.g. the Nesbit-grassland drill used to plant small seeded grasses such as Weeping lovegrass, *Eragrostis curvula*, are ideal for planting bermudagrass seed in various row spacings. The Brillon[3] seeder can be used with excellent results if a broadcast stand and rapid cover is desired.

Insects Associated with Seed Production

A major problem in forage grass seed production is the lack of full seed-set despite optimum fertility and moisture regimes. With seed production of certain grasses (Ahring, 1965; Ahring and Howell, 1968; Hardison et al., 1958; Nielson and Burks, 1958; Starks and Thurston, 1962) it is apparent that insects, some of which are minute, cause considerable reduction in seed-set and resultant seed yields. The minute insect species inhabiting bermudagrass seed production blocks at El Reno, Oklahoma, are listed in Table 1. Populations of these small insects multiply almost unnoticed. The effects and relationships of some of these insects on bermudagrass seed production are unknown. The list of small insects is not complete and possibly many more species can be added.

Some of the species reported are known to be plant feeders and cause damage to other forage crops, e.g., *Therioaphis maculata* (Buckton), the spotted alfalfa aphid, etc. Others, such as the small parasitic wasps, *Telenomus* spp., could be beneficial, and certain thrips may aid pollination. In effect, although numerous insect species infest bermudagrass seedheads, as a whole they do not appear to reduce seed yields.

In the event insect problems arise, growers should consult their county extension agent for assistance in formulating control measures.

[3]Mention of a trade mark or proprietary product does not imply a guarantee or warranty of the product by the USDA or Oklahoma State University nor imply approval to the exclusion of other products that may also be suitable.

Table 1. Minute Insects Collected Among the Floral Parts of Bermudagrass Grown for Seed[1]

Order and Family	Genus and Species	Types of Insects
COLEOPTERA		beetle, weevils, twisted-winged insects (chewing mouth parts)
Chrysomelidae	*Chaetocnema* sp. (near *denticulata* Illiger)	
Elateridae	*Conoderus bellus* (Say)	
Lathridiidae	*Coaticaria* sp.	
Mycetophagidae	*Typhaea stercorea* (L.)	
Phalacridae	*Stilbus* sp.	
COLLEMBOLA		spingtails
Sminthuridae	*Deuterosminthurus* spp.	
DIPTERA		Flies, midges, mosquitoes, etc. Mouth parts- chewing (larvae) piercing-sucking (adult)
Cecidomyiidae	*Anarete johnsoni* (Flet.)	
Chironomidae	Orthocladiinae genus and sp. unidentified	
Chloropidae	*Oscinella minor* (Adams)	
	Oscinella spp.	
	Siphonella spp.	
Empididae	*Drapetis* spp.	
	Platypalpus spp.	
Pipunculidae	Genus and sp. unidentified	
Sciaridae	*Bradysia* sp.	
Tephritidae	*Neotephritus finalis* (Loew)	
Tabanidae	*Silvinus pollinosus* (Williston)	
HEMIPTERA		true bugs, e.g. stink bugs, plant bugs
Miridae	Genus and sp. unidentified	
Pentatomidae	Genus and sp. unidentified	
Tingidae	*Gargaphia solani* Heidemann	
HOMOPTERA		aphids, leaf-hoppers, white flies, scales etc. (sucking mouth parts)
Aphididae	*Therioaphis maculata* (Buckton)[2]	
Cicadellidae	Cicadellinae genus and sp. unidentified	
	Deltocephalus sonorus Ball	
	Deltocephalinae genus and sp. unidentified	
Coccoidae	Genus and sp. unidentified	

Table 1. Minute Insects Collected Among the Floral Parts of Bermudagrass Grown for Seed (Cont.)

Order and Family	Genus and Species	Types of Insects
HYMENOPTERA		sawflies, chalcids, ants, wasps, etc.
Encyrtidae	*Aphidencyrtus aphidivorus* (Mayr.)	(chewing mouth parts)
	Trichomasthus sp.	
Eupelmidae	*Eupelmus allynii* (French)	
Formicidae	*Solenopsis* (Diplorhoptrum) sp.	
Mymaridae	*Gonatocerus* sp.	
	Patasson sp.	
Scelionidae	*Telenomus* spp.[3]	
Sphecidae	*Pluto sayi* (Rohwer)	
LEPIDOPTERA		butterflies, moths
Noctuidae	*Spodoptera frugiperda* (J. E. Smith)	
PSOCOPTERA		
Peripsocidae	*Ectopsocopsis cryptomeriae* (Enderlein)	
THYSANOPTERA		thrips
Aeolothripidae	*Stomatothrips brunneus* (J. C. Crawford)	
Phlaeothripidae	*Eurythrips* sp.	
Thripidae	*Chirothrips simplex* Hood	
	C. mexicanus (D. L. Crawford)	
	Chirothrips sp.	
	Chirothrips spiniceps Hood	
	Frankliniella fusa (Hinds)	
	F. occidentalis (Pergande)	
	F. tritici (Fitch)	
	Microcephalothrips abdominalis (D. L. Crawford)	
	Plesiothrips sp.	

[1]Southwest Livestock and Forage Research Station, El Reno, OK.
[2]Spotted alfalfa aphid
[3]Numerous

Production System

From the information cited, as well as our long experience with bermudagrass seed production, we have developed the production system outlined below for prospective growers.

Bermudagrass will produce two seed crops per year, summer and fall. Since the second or fall crop is generally small, a grower in Oklahoma should be concerned only with the summer (August) seed harvest. The fall growth can either be grazed or baled for hay. In either event, residual litter on fields should be burned or mechanically removed in early March of each year. Removal of thatch or field litter in the spring aids in the control of weeds, promotes early growth, and increases the effectiveness of cultural and other management practices.

Establishment Management

During the establishment of foundation seed fields, sprigs (rhizomes and stolons) of cross-compatible clones can be alternately planted in rows spaced as far apart as 12 feet (3.6 m) if planted early in the season, March to early May. Later planting dates, June through July, require narrower row spacings to insure a sod cover by frost. After sprigging the field, use a pre-emergence herbicide such as simazine to control weeds and weedy grasses. Use the rate recommended on the label for soil type. After sprigs start to emerge, nitrogen should be applied to stimulate growth. If watered properly a complete cover can be obtained prior to frost.

In the spring of the year following establishment, seed production fields should be mowed short and residue removed mechanically, but not burned. Burning a new field in March the year after sprigging may reduce the field cover and set the field back. Most spring growth occurring 2 to 3 feet (0.6 to 1 m) from the center of each sprigged row, and especially in the overlap areas between rows, originates from bud clusters on the plant runners (stolons). In the older part of the rows, however, growth occurs from both bud clusters on stolons and from rhizomes. Growth derived from underground rhizomes is not susceptible to or injured by burning. Two-year-old stands can be burned without reducing field cover or sod density.

Cultural and Management Practices

The most important cultural practice in the production of bermudagrass seed, provided other nutrients (P, K) are adequate, is nitrogen fertilization. The rate needed and time of application are important management decisions. Too much nitrogen applied to young established fields tends to promote forage production and reduce seed yields. Forage production, if heavy, interferes with and slows seed harvesting. The older the field becomes, the greater the need for higher nitrogen fertilization rates. The how and when of doing the things needed to produce high seed yields are more important than are cultural practices. The management sequence and cultural practices on 2-year-old and older stands are:

1. Remove all fall crop residue by burning or by mowing and baling in early March.
2. Apply a pre-emergence herbicide (simazine) in March after removal of the previous year's residual growth, but do not fertilize. Where cool season weeds and weedy grasses are, or become, a problem a fall application of a pre-emergence herbicide will be needed.

3. Irrigate (4 to 5 inches) if needed during April to promote spring growth.
4. Mow and bale spring growth during the first week of May. Spring is a period of rapid vegetative growth, and if the growth is not removed it reduces summer seed yields. This early growth must be removed in May prior to fertilization.
5. Fertilize with 60 to 90 lb nitrogen per acre (67 to 101 kg N/ha) immediately following the May mow-back and forage removal. Unlike fields maintained for grazing, high fertilization rates which produce high forage levels are not needed for bermudagrass seed production.
6. Soil moisture from early rainfall and/or irrigation water is normally sufficient to promote regrowth after the May cut-back. *Regrowth following fertilization should be uniform, followed in June and July by alternate wet-dry climatic conditions.* Normally, June and July do not have prolonged wet cycles. Extended dry weather during either month should be interrupted by irrigation. During these months the alternate wet-dry cycle (rapid growth and stress periods) promotes a limited flush of new growth and then seedstalk initiation and flowering in the early to mid-stage of each stress cycle. Two or three complete cycles are needed to produce a good seed crop in August. The higher the number of seedstalks produced during June and July, the greater the seed yield potential. If managed properly, yields in excess of 1000 lbs of seed/acre (1121 kg/ha) are possible.
7. Producing a fall seed crop depends on how soon the grower is able to harvest and remove the field litter of the summer seed crop, fertilize and irrigate, etc. In parts of Oklahoma and Texas, two annual seed crops may be possible. Even in areas where fall seed crops may be terminated by frost, subsequent *spring growth and summer seed yields appear to benefit from a late summer or early fall application of 60 lbs N/acre.* Good fall growth promotes a) healthy plant root systems during the dormant winter months, b) stimulates vigorous spring growth following residue removal, c) aids in controlling the encroachment of weedy annual grasses, and d) increases summer seed yield potential.

Seed Harvesting

A summary of several methods that may be used by growers in harvesting bermudagrass seed are:

1. Swath the field and allow the windrow to cure to a uniform dryness; then combine. In order to maximize seed yield, combined tailings must be rethreshed three or four times or until little or no seed is obtained by additional threshing operations. Only 20 to 30 percent of the total seed is harvested in the first thresh.
2. Spray-apply a drying agent (desiccant), such as paraquat or diquat, at recommended rates to bring the standing vegetation to a uniform acceptable dryness; then combine harvest. Direct combining a well cured field on a first-over basis will result in harvesting 40 to 50 percent of the total seed crop. Combined tailings must be rethreshed two to three times or until little or no seed is obtained by additional threshings.
3. Spray-apply a drying agent as above, but utilize a stripper harvester, similar to the Australian seed stripper, in the first thresh operation, followed by direct combining and rethreshing the combined tailings once or twice as needed. The

stripper harvester used after crop desiccation was the most efficient harvest method studied. Between 50 and 60 percent of the seed crop was obtained in a once-over operation. However, this machine is a small plot harvester and is not commercially available in large models.

Bermudagrass does not shatter seed readily, but retains its seed on the inflorescences for long periods of time. Thus, the method used in harvesting and failure by the grower to rethresh the combined tailings can reduce yields, and likewise income. The combine setting is also critical in harvesting bermudagrass seed. The most efficient combines are those having the highest threshing capacity. The combine air-flow should be completely closed and all inspection and cleaning plate openings in the seed delivery system should be taped to prevent seed losses through cracks and crevices.

Advantages of the Use of Desiccants in Harvesting

Spray-applied drying agents that bring the standing crop to a uniform dryness acceptable for direct combining, without windrow curing, can speed up harvest and reduce costs. The desiccants that worked best for us were paraquat and diquat applied at 0.25 and 0.50 lb active ingredient at 60 psi, respectively, in 20 gallons of water per acre. The dinitro desiccants evaluated in a preliminary study were not satisfactory. Four to five days were required to cure the field following the spray-application of desiccants, whereas 10 to 14 days under the same climatic conditions were required to adequately cure a swathed crop. Although the rate of moisture loss in the vegetative canopy after spray-application was not measured, paraquat visually appeared to be slightly better than diquat, but both were superior to dinitro desiccants. These observations were further substantiated by the ease in which the combine handled the direct-harvest of the treated areas, the amount of seed harvested, and the time required to harvest a given distance.

In summation, no initial swathing operations were required, less time was required for curing, a higher harvest efficiency was measured per thresh, and the number of rethreshs of the combine tailings was reduced by one in comparison to the conventional swath-cured method of harvesting.

Desiccant Disadvantages

Paraquat is potentially dangerous. Label precautions should be strictly followed when making applications. Dust particles in harvesting and cleaning may also present a potential health hazard. Diquat is reasonably safe to use, but is not as effective in curing bermudagrass as paraquat. Other desiccants not evaluated by us may work well.

Another disadvantage to using paraquat as a desiccant is its observed effect on germinability of the harvested (unhulled) seed. However, hulling the seed harvested from paraquat over-sprayed seed fields removed the paraquat effect. In most instances seed sold in commercial channels are naked caryopses, with the subtending appendages removed (dehulled).

Weed Control

Properly managed bermudagrass is very competitive with other plant species. This competition is effective in preventing problems with most annual weeds, but is not very effective in crowding out the perennial weed. For this reason, weeds need to be controlled both during and after fields are established. Many weed seedlings (both broadleaf and weedy grasses) can be controlled with simazine. In an established seed field, simazine should be applied soon after removal of the previous year's crop residue.

Most broadleaf weeds can be controlled with 2,4-D during establishment and in established fields. Horse nettle and silver nightshade are two perennial broadleaf weeds that, in some fields, may be a continuing problem. These plants cannot be eradicated, but can be suppressed by spraying with a mixture of 2,4-D and Dicamba. Johnsongrass can be selectively removed by applying glyphosate (Roundup) with a wick applicator and/or isolated plants can be removed by a spot-spray wetting of glyphosate with a hand sprayer.

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