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Chapter 3

ESTABLISHMENT, MANAGEMENT AND SEED PRODUCTION

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ESTABLISHMENT, MANAGEMENT AND SEED PRODUCTION

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Forage crop management involves the use of available "tools", including cultural practices, by the producer to economically grow desired amounts of quality forage. Available tools are adapted varieties, fertilizer, agricultural chemicals and irrigation, which are used to maintain optimum production of the forage plant. Cultural practices involve method, rate, date of seeding; kind, rate, and date of fertilizer applications; cutting height and frequency; and weed control. Pasture management is more than adapted forage varieties and fertilizer application--above all, it involves the meeting of cattle and forage. It also involves the farmer's or rancher's choice of a particular tool or practice and its time of application for his pasture program. Research is conducted on various management practices by The Texas Agricultural Experiment Station to help producers make correct decisions toward better forage production.

PASTURE ESTABLISHMENT

Seedbed preparation, time and rate of seeding, fertilizer kind and rate, and weed control practices are the major management tools used in establishing forage species--whether alone or in mixtures. These management practices are used to favor the growth of desired species over undesired species which may be present. Seedbed preparation frequently is given inadequate attention, and yet most grasses and legumes have smaller seed and less vigorous seedlings than the larger seeded field crops. A clean, firm seedbed is required for optimum stand establishment. Seed should be placed in the soil at the proper depth, generally from ¼ to 1 inch deep, depending on seed size.

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Planting at the proper time will give the forage plant opportunity to compete with weeds and provide the best temperature and moisture environment for germination.

Research information is not available on the establishment of all grasses and legumes. However, studies have been conducted with some species and results are presented to demonstrate the principles mentioned. Planting date and seeding rate are two of the factors receiving most attention.

Small Grains

Winter cereals such as wheat, oats, rye, barley, and hybrids within and between these are used extensively for forage. These are all seeded in the fall, but there is no fixed date of seeding for winter and spring forage production. Planting may be done from August to late November, depending on temperature and moisture conditions. The seedlings emerge shortly after planting, if moisture is adequate, and grow rapidly until the onset of cold temperatures. Relatively little growth may be made in mid-winter in Central and North Texas, depending on temperature. However, growth may continue through the winter at a reduced rate in South Texas and intermittently in more northern areas. Growth is rapid in early spring and ceases with grain development and maturation.

Date of seeding has a significant effect on early forage production and also on total forage production (Table 3-1). Plantings made after October 1 will have little or no forage available by December 1. Peak total harvested forage yields are obtained from October 15 seeding date at College Station. Seedings prior to September 15 or after November 1 usually produce less harvested forage.

Clipping generally reduces the potential dry-matter production of small grains (Table 3-1). A single harvest only at maturity results in maximum production and shows the influence of seeding date in the absence of clipping effects. Kinds and varieties may respond differently to seeding date. Gator rye shows peak total production from November 1 seeding, Mustang oats from October 15 seeding, and Suregrain oats varies little from October 1 to November 1 seedings. Late seeding (after November 1) appears to restrict potential yields more than early seeding.

Certain problems may be encountered with early seedings which are less likely to

Table 3-1. Forage yield of small grain varieties with various date of planting, College Station (3-year average).

Planting date	Variety	Harvestable forage December 1	Total yield of 3 - 4 clippings	Total yield, harvested only at maturity
		Pounds dry forage/acre		
Sept. 1[1]	Gator rye[2]	360	1,840	
	Mustang oats	790	1,460	
	Suregrain oats[3]	960	1,710	
Sept. 15	Gator rye	700	2,530	4,260
	Mustang oats	710	2,050	3,350
	Suregrain oats	920	2,210	3,880
Oct. 1	Gator rye	590	2,240	4,100
	Mustang oats	690	2,120	3,600
	Suregrain oats	940	2,160	4,050
Oct. 15	Gator rye	230	2,940	4,680
	Mustang oats	210	2,610	4,630
	Suregrain oats	410	2,900	4,260
Nov. 1	Gator rye	0	2,570	5,370
	Mustang oats	0	2,310	3,500
	Suregrain oats	0	2,180	4,250
Nov. 15	Gator rye	0	2,470	3,840
	Mustang oats	0	1,980	3,240
	Suregrain oats	0	1,830	2,800
Dec. 1	Gator rye	0	1,590	3,490
	Mustang oats	0	1,850	2,960
	Suregrain oats	0	1,330	2,360

[1]Yields are based on only one year and adjusted for year effects.

[2]Cordova barley was used instead of Gator rye one year.

[3]Moregrain oats was used instead of Suregrain oats one year.

Holt, Norris and Lancaster, 1969.

occur at later seedings. Three major problems are insects, drouth, and weeds. These are reduced or eliminated with the advent of cool weather. Early seeding is necessary for early fall or early winter forage production, and if the major need is for late fall and early winter forage, some sacrifice of total production may be desirable in order to obtain early forage. Thus, the risks involved in early planting do not eliminate the desirability or necessity of early planting where fall or early winter pasturing is to take place.

Seeding rates within the limits of 48 and 112 pounds per acre do not influence total forage production. Early production at Crystal City (Holt, Norris, and Lancaster, 1969) was increased with the higher rates of seeding, but total production with 96 pounds of seed was only 500 pounds above that with 48 pounds. Available forage on December 1 in a study at College Station was increased by a maximum of 260 pounds due to a heavy seeding rate (Holt, Norris, and Lancaster, 1969). Similar results were obtained at Kirbyville where yields varied less than 700 pounds with seeding rates from 48 to 112 pounds per acre. It probably is advisable to use 64 to 80 pounds of seed per acre to insure a satisfactory stand for fall and early winter pasturage.

Grasses

Perennial grasses are more difficult to establish than annual grasses, not only because of the small seeds which require precise placement in the soil, but also because of generally poorer seed quality. Furthermore, the seedling of perennial grasses is weaker and grows much more slowly than that of annual weeds (Figure 3-1). Thus, establishment, especially of warm-season grasses, frequently is hazardous and is one of the major cost factors in grass production. The usually small seeds dictate placement at or near the surface of the soil for seedling emergence. The warm-season types are planted in spring and early summer when moisture for germination is lost rapidly from the surface layer of soil. Certain annual grasses of the weedy type frequently compete during establishment while the grass seedling is growing slowly. While none of these factors can be overcome completely, the use of appropriate establishment practices will reduce their negative effect on establishment.

Moisture limitations and weed competition suggest that time and rate of seeding, weed control, and fertilization are important factors in the establishment and early forage production of perennial grasses. Research (Holt and Hutson, 1954, and Dudley and Holt, 1963) indicates that time of seeding is particularly important. Winter, or dormant-season, seeding of grasses with slow germination, such as dallisgrass, bahiagrass, and buffalograss, is generally superior to spring or summer planting. On the other hand, spring planting of rapidly germinating species, such as blue panicgrass, switchgrass, and rhodesgrass, is preferred.

Weed competition may be a major factor, particularly with early or dormant-

Figure 3-1. Weed competition with Kleingrass in the seedling stage.

season planting, in that the weeds have an opportunity to become established prior to emergence of the permanent grass. The use of a companion or mulch crop to reduce weed competition has been successful under some conditions (Holt and Hutson, 1954). The practice may be useful where moisture is not a major limiting factor but is not suggested in the lower rainfall areas (Dudley and Holt, 1963) because of competition by the companion crop for the available moisture.

Seeding rate and fertilizer rate as well as weed control are important in the establishment and early forage production of perennial grasses. Dallisgrass seed germinate slowly, apparently because of the impervious covering surrounding the seed. Not nearly all the seed units contain an actual seed, and seed viability is lost in storage, especially in the summer. Because of these characteristics, dallisgrass establishment may show a positive response to seeding rate (Table 3-2). However, an even greater response to weed control is apparent and may be expected where weed competition is a factor. The response to fertilization will depend on soil type and condition, but one or more of the plant nutrients are generally needed. In the study reported in Table 3-2, early production which would indicate rate of establishment showed a response to phosphorus and a further response to nitrogen in the presence of phosphorus; thus, both are needed in this case.

Some species emerge more slowly than others, and heavy seeding rates may be necessary for satisfactory early stands (Table 3-3). Fall seedings of warm-season grasses, even in the Coastal area, may occasionally encounter winter damage and some loss of stands (Table 3-3). Factors contributing to the reduced stand in this case were heavy frosts in early December and the use of 2,4-D for weed control in mid-December.

Perennial grasses spread by tillers, rhizomes, or both, as well as by seed. The grass stands reported in Table 3-4 represent approximately six weeks' development of seedlings recorded in Table 3-3. Dallisgrass spreads quite rapidly, and only a few established seedlings per square foot are necessary. Bahiagrass spreads much slower than dallisgrass but will continue to increase under competition. Competing crabgrass and other grasses resulted in some decrease in dallisgrass stands after mid-summer, whereas the stand of bahiagrass continued to increase.

Table 3-2. Dry-matter yields of dallisgrass as influenced by seeding rate, nitrogen, phosphorus and 2,4-D.[1,2]

2,4-D	Nitrogen	No phosphorus 4 lb. seed	No phosphorus 8 lb. seed	50 lb. phosphorus 4 lb. seed	50 lb. phosphorus 8 lb. seed
		Lb. forage/acre three months after planting			
None	0	1,313	891	1,103	1,765
"	25	1,455	1,100	1,245	1,406
"	50	981	1,123	1,565	2,165
1 lb./ac	0	1,888	2,446	3,907	3,795
"	25	1,765	2,701	4,827	4,233
"	50	1,955	2,817	5,411	4,401
		Total lb. forage/acre for first year			
None	0	2,768	2,075	2,697	3,175
"	25	2,810	2,368	2,619	3,175
"	50	2,207	2,401	3,414	3,669
1 lb./ac	0	3,333	3,924	5,608	5,479
"	25	3,104	4,027	6,734	5,872
"	50	3,385	4,382	7,024	6,163

[1]Original data were collected by R. H. Brown at Texas A&M University Research and Extension Center at Beaumont.

[2]Application of 2,4-D to eliminate weeds was the only significant treatment effect at the .05 level.

Table 3-3. Dallisgrass and bahiagrass plants per square foot on two sampling dates as influenced by seeding rate.[1]

Sampling date and species	Seeding rate, lb./acre 2	4	8	16
November 30, 1966				
Dallisgrass	4.1a[2]	9.6a	17.6b	33.2c
Bahiagrass	1.6a	4.0a	6.0ab	9.4b
June 8, 1967				
Dallisgrass	1.3a	2.1a	2.2a	4.2b
Bahiagrass	0.4a	0.7a	1.4ab	2.4b
Percent reduction in stand				
Dallisgrass	68.0	78.0	88.0	87.0
Bahiagrass	75.0	83.0	77.0	75.0

[1]Original data collected by R. H. Brown at Texas A&M University Research and Extension Center at Beaumont.

[2]Values within a line with the same letter do not differ significantly.

Table 3-4. Visual estimates of percentage stands of dallisgrass and bahiagrass at two dates in 1967.[1]

Species and dates	Seeding rate, lb./acre 2	4	8	16
Dallisgrass				
July 21	69a[2]	75a	82a	81a
September 26	53a	59a	67a	74a
Bahiagrass				
July 21	16a	15a	23ab	33b
September 26	18a	34ab	48b	57b

[1]Original data collected by R. H. Brown at Texas A&M University Research and Extension Center at Beaumont.

[2]Values within a line followed by the same letter are not significantly different.

Grass-Legume Mixtures

Establishing a grass-legume mixture is complex because there are two or more species involved with different germination, growth, and fertility characteristics. Grasses require nitrogen, phosphorus, and potassium, while well-nodulated legumes require only phosphorus and potassium. Thus, a major factor in establishment is proper fertilization. The effect of fertility level on establishment is shown by forage production in the summer following fall planting of dallisgrass-white clover and Coastal bermudagrass-white clover mixtures. Good stands of dallisgrass and white clover were established, but Coastal bermudagrass spread very slowly so that adequate stands were not obtained in the first growing season. Early season production, represented primarily by clover, increased as phosphorus increased, whereas late season production, represented by the grass component, increased as nitrogen level increased (Table 3-5). White clover made up about 75 percent of the forage in the dallisgrass plots and about 90 to 95 percent in the Coastal plots in May. Clover percentages decreased later in the season, particularly where no phosphorus was applied and at the 150-pound nitrogen rate. Very little clover growth occurred in the second year in plots receiving no phosphorus. Thus, both nitrogen and phosphorus are important in grass-legume establishment and subsequent production.

EXAMPLES OF PLANT RESPONSE TO CLIPPING

The removal of above-ground parts of plants by grazing or mowing affects plants in different ways. It is necessary to have some knowledge of these effects in order to properly manage a grass or legume stand. The responses involve or affect yield and quality of forage, but the effect may be indirect through changes in density, stand longevity, plant vigor, and photosynthetic efficiency. Clipping rather than grazing is frequently used to measure these responses, since clipping studies can be conducted in small plots, whereas grazing requires a much larger investment in land and animals.

The responses to clipping of winter annuals, a sod-type perennial and two erect or bunch-type perennial grasses, will be presented in this section to demonstrate some types of responses.

Table 3-5. Yields of dallisgrass-white clover and Coastal bermudagrass-white clover mixtures as influenced by nitrogen and phosphorus fertilization, 1967.[1]

Nitrogen lb./acre	Phosphorus lb./acre	Yield, lb./acre			
		May 31	Aug. 3	Sept. 19	Total
		Dallisgrass			
0	0	159	377	559	1,096
0	50	1,055	561	520	2,137
0	150	1,457	944	554	2,955
75	0	135	547	912	1,595
75	50	856	799	881	2,536
75	150	1,312	1,050	990	3,352
150	0	344	980	1,244	2,568
150	50	944	1,295	1,162	3,400
150	150	1,534	1,694	1,358	4,586
		Bermudagrass			
0	0	68	27	179	273
0	50	554	288	133	975
0	150	874	305	295	1,474
75	0	51	181	774	1,007
75	50	573	315	617	1,505
75	150	881	474	641	1,996
150	0	94	462	1,181	1,738
150	50	680	634	987	2,301
150	150	1,229	828	1,007	3,064

[1]Original data collected by R. H. Brown at Texas A&M University Research and Extension Center at Beaumont. Plots were planted in October 1966.

Small Grains

Grazing, clipping, or other method of harvesting small grains used for forage should strive for maximum sustained forage production without early damage to stands. The management system should be economical and practical, taking into consideration total production and the time and distribution of the forage produced, whether for pasture or silage.

Under both field and greenhouse conditions, oats produce more than twice as much total forage for the season when allowed to grow to a height of 14 to 16 inches than when utilized as soon as they reach 3 to 4 inches or 8 to 10 inches in height (Holt, Norris, and Lancaster, 1969). Clipping when 3 to 4 inches high is more detrimental than clipping when 8 to 10 inches high. Oat yields may be reduced more than those of barley. Under field conditions, barley yields from 8- to 10-inch growth have been only 10 percent less than from 14- to 16-inch growth, while the yields for oats have been reduced 59 percent with the same treatment. Clipping effects probably are more severe than normal livestock grazing effects because clipping removes all the forage at one time.

In these studies, the best root development on oats and barley occurred when they attained a height of 14 to 16 inches before clipping. Plants clipped at 3 to 4 inches of growth showed poor root development, and those at 8 to 10 inches showed moderate development. This points out the importance of allowing small grains to become well established before grazing by livestock.

The importance of proper management of small grains used for winter pasture is further emphasized by work at College Station (Table 3-6). Frequent defoliation reduced seasonal and total yields to less than half that with less frequent defoliation. Figure 3-2 shows the growth of plants in this study.

Plants may reach a height of 4 to 6 inches by mid-November and not reach a height of 10 to 12 inches until early January. The grower must decide whether utilization during this period is more important than greater total production for the season. However, it is important to allow oat plants to become well established before grazing starts, and if frequent close utilization reduces production by as much as 1500 pounds

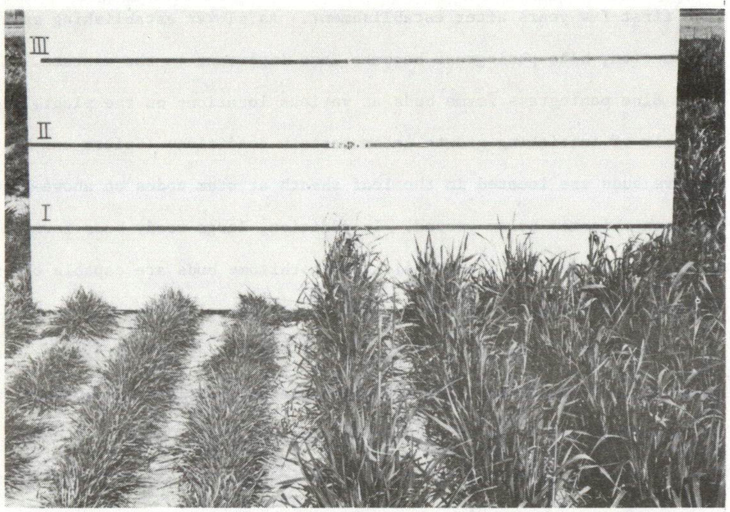

Figure 3-2. Mid-winter growth of prostrate winter-type (left) and erect spring-type small grain varieties, College Station.

Table 3-6. Average forage yield, pounds/acre, of two oat varieties clipped at two heights of growth, College Station.

Height at clipping, inches	Season of harvest[1] Early winter	Mid-winter	Early spring	Total
4- 6	485	450	615	1,550
10-12	985	1,005	1,180	3,170

[1]Dates of clipping:

Early winter: 4-6 inches: November 18, December 1, December 17 and January 3
10-12 inches: January 3

Mid-winter: 4-6 inches: January 20, February 9 and February 24
10-12 inches: February 24

Early spring: 4-6 inches: March 7, April 15
10-12 inches: April 15

Holt, Norris and Lancaster, 1969.

per acre, the value of production in this system might be questionable.

Defoliation practices influence root and crown development of oats as well as forage production (Table 3-7), and the effect is similar on both erect and prostrate types (Figure 3-2). By December 20, a greater tonnage of dry matter is produced by plants unclipped to that time than by plants that have been clipped 2 to 4 times. Frequent clipping (10-day interval) may reduce production of the erect variety as much as 47 percent then compared with infrequent (40-day) clipping and 58 percent when compared with clipping only at maturity. The reduction in yield due to frequent clipping is slightly less for prostrate varieties than for erect variety.

Crown and root development follow the same pattern as dry-matter production. Apparently, more frequent clipping reduces tillering and results in a smaller crown which in turn reduces the potential for top growth. Following frequent defoliation, crowns may weigh only 37 percent as much as following infrequent defoliation (40-day intervals). Approximately half the above-ground development is in the crowns but before the usual cutting or grazing height.

Table 3-7. Top and root growth of oats of different growth habits and with various clipping frequencies, Lufking fine sandy loam soil, College Station.

Early growth habit	Harvest frequency (days)	Pounds dry matter/acre Forage (above crowns)	Crowns (below cutting ht.)	Roots
Erect	10	1,060	490	390
	20	2,030	810	415
	40	2,040	1,140	540
	Maturity	2,550	2,720	640
Prostrate	10	1,280	760	500
	20	1,780	1,600	595
	40	2,300	2,190	710
	Maturity	2,370	3,170	810

Holt, Norris and Lancaster, 1969.

Root production in the top foot of soil also is reduced by frequent defoliation, but to a lesser extent than top and crown development. Roots from frequently clipped plants weigh about 30 percent less than roots from infrequent clipping.

Frequent clipping can retard root development, thus reducing the plant's ability to take up moisture and nutrients. This would cause it to suffer from drouth earlier than it would with extensive root development. Reduced crown development reduces the area from which growth takes place and leaves more of the soil exposed to evaporation and water loss from runoff. All these factors and others are important in developing a grazing management program for winter annual grasses. The data indicate the desirability of delaying the first grazing until the plants are well established. Subsequent grazing or utilization would provide for either adequate residual leaf area for recovery growth or an adequate recovery period between grazing or utilization.

Blue Panicgrass Management

Blue panicgrass (Panicum antidotale Retz.) is a tall, rhizomatous, perennial warm-season bunchgrass introduced from Africa and India (Figure 3-3). Its use in Texas has been limited to South Texas and areas west of the Blacklands and Grand Prairie.

Blue panicgrass is succulent and nutritious in the young stage but becomes fibrous and woody at maturity.

Blue panicgrass has a vigorous seedling and is relatively easy to establish. It is highly productive the first year but loses vigor (and sometimes the stand) in subsequent years. Because of these characteristics, its primary use in recent years has been as a component in range reseeding mixtures where its main contribution is in the first few years after establishment. As slower establishing species come into production, blue panicgrass becomes less important in the mixture.

Blue panicgrass forms buds at various locations on the plant, and these buds are capable of initiating growth under certain conditions (Spiers and Holt, 1970). Vegetative buds are located in the leaf sheath at stem nodes on above-ground stems and also on rhizomes below ground. In addition, large woody buds form at the base or crown of the plant (Figure 3-4). While rhizome buds are capable of producing shoots at any time during the growing season, they actually function in this capacity mainly in initiating spring growth and growth following drouth dormancy. The potential activity of crown buds seems to be restricted after mid-June. Thus, rhizome and crown buds, though producing an occasional vigorous shoot, seem to function largely as drouth and cold survival mechanisms in blue panicgrass. Their activity under field conditions apparently is restricted by hormones within the plant system, depth in the soil, lack of light, or other factors. That some or all of these factors are involved is indicated by the fact that tillage of old stands or disturbance of the plants has resulted in extensive, vigorous plant development from rhizome and crown buds. Most regrowth following defoliation occurs from aerial stem buds, which show a decreased capacity for initiating growth and less vigor of shoot growth after early June. Thus, initial spring growth is most abundant and vigorous, and regrowth during the season may be slow or weak.

Several studies have been conducted in an effort to overcome the problem of loss of productivity with years. Since blue panicgrass is tall growing, close or frequent defoliation is assumed to be contributing factor in reducing vigor. Similarly, since the grass is high in protein (nitrogen) content, nitrogen fertilization is assumed to be an important factor. Blue panicgrass management studies at College Station and

Figure 3-3. Blue panicgrass

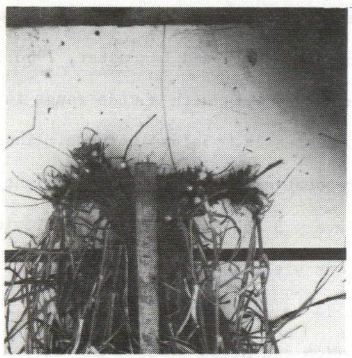

Figure 3-4. Blue panicgrass plant showing crown and rhizome buds.

Iowa Park (Holt, 1967) have shown that nitrogen fertilization, harvest frequency, and cutting height influence yield within a growing season and may influence yield to some extent in succeeding years. However, yields decline in succeeding years, even with the most favorable practices.

Further research using extremely high nitrogen rates and a wide range in harvest frequency (Table 3-8) has shown that production can be maintained over an extended period of years.

Table 3-8. Blue panicgrass forage yields as influenced by nitrogen and harvest frequency. Texas A&M University Farm near College Station, 1967-1970.

Harvest frequency (weeks)	Nitrogen rate (lb. N/A)	Pounds dry forage/acre				
		1967	1968	1969	1970	Average
3	120	1,781	2,012	2,289	3,170	2,314
	240	3,738	4,168	4,709	8.325	5,236
	480	5,291	6,042	6,687	9,580	6,901
	960	6,066	5,973	6,297	7,598	6,484
6	120	2,410	3,248	4,474	4,929	3,765
	240	5,226	7,793	7,239	7,888	7,037
	480	9,240	10,790	11,534	9,394	10,240
	960	11,574	12,970	13,173	11,818	12,384
9	120	3,615	5,560	3,805	7,840	5,205
	240	7,204	13,655	7,473	10,480	9,703
	480	11,480	16,361	11,898	11,758	12,874
	960	13,786	18,586	15,193	13,847	15,353
Average (yr.)		6,784c	8,930a	7,898b	8,887a	

Effects of N rate, harvest frequency and year were significant (P<.01).

SUMMARY OF MAIN EFFECTS

Cutting frequency	Pounds N/acre				
	120	240	480	960	Average
3	2,314	5,236	6,901	6,484	5,234a
6	3,765	7,037	10,240	12,384	8,357b
9	5,205	9,703	12,874	15,353	10,784c
Average (yr.)	3,761a	7,325b	10,005c	11,407d	

Values with a line or column followed by the same letter do not differ significantly.

Within a harvest frequency, average yields generally increase with increased nitrogen rates except that frequent harvests limit production potential of the plant so that it cannot respond to as much nitrogen as less frequently defoliated plants. While the most efficient nitrogen response in terms of forage per pound of applied nitrogen may be at lower rates, it seems evident that high rates are necessary for a satisfactory yield level. The nitrogen level required for optimum production will vary with soil type and rainfall or available moisture. These data indicate that with adequate nitrogen, blue panicgrass can be very productive over prolonged periods.

Average yields by years (Table 3-8) do not indicate that sustained vigor is particularly responsive to either nitrogen rate or defoliation intensity. The stand was two years old at the time the study was started and had already lost some vigor. Yields in succeeding years either increased or did not change except for the two highest nitrogen rates at the 9-week frequency. In no case was the fourth year's yield less than the first year's yield. Stand loss occurred with 3-week harvesting at both 120 and 240 pounds of nitrogen and with 6-week harvesting at 120 pounds of nitrogen. Thus, yields in the latter years with these three treatment combinations must be discounted, since a high percentage of invading species was involved.

These data suggest that dry-matter production of blue panicgrass may be maintained at a fairly uniform level over an extended period of time with any treatment combination with which stands can be maintained. Above the minimum maintenance requirements, yields increase with increased nitrogen rates and decreased defoliation intensity. Secondly, the influence of increasing defoliation intensity on stand maintenance may be offset to some extent by increased nitrogen levels, since stands can be maintained under more frequent defoliation with high nitrogen rates.

Thus, it appears that (1) blue panicgrass yields are highly responsive to nitrogen and harvest practice; (2) yields may be fairly uniform over time following the initial production year (yield level being dependent on management practices); (3) a stabilized production level of 4 to 5 tons of dry matter per acre is possible with moderate defoliation and adequate nitrogen and (4) loss of stands will occur at no nitrogen or low nitrogen fertilization, and the loss is intensified by frequent defoliation.

Blue panicgrass has a high nitrogen content, and both nitrogen content and yield are increased with increasing fertilization. Efficiency of nitrogen recovery or utilization is relatively good even at high N rates. In the above study, applied nitrogen recovered in the harvested growth the first year was 82, 94, 77, and 49 percent for rates of 120, 240, 480, and 960 pounds applied nitrogen per acre, respectively (Spiers, 1969). Thus, even at 480 pounds per acre, efficiency of utilization was satisfactory. However, by the third year recovery percentages had dropped to 63, 56, 55, and 31 percent, respectively, for the four nitrogen rates.

Coastal Bermudagrass Management

Coastal bermudagrass (Figure 3-5) is widely used as a pasture and hay plant in Texas. Numerous studies have been conducted on the response of Coastal to fertilization and harvest frequency in terms of both forage yields and quality, but relatively little emphasis has been placed on stand maintenance and sustained vigor in these studies. Neither has height of cutting received major attention, likely because Coastal is a rhizomatous sod-forming plant which seldom presents major problems in stand survival. However, ground cover may be important for other reasons, and plant residues following cutting or grazing could influence vigor as well as longevity.

Yields of Coastal and most perennial grasses decrease as the frequency of top growth removal increases (Holt and Lancaster, 1968). However, the decrease is not as much as might be expected even with a wide range in frequency (Table 3-9). Conversely, as clipping height decreases, yields increase. Thus, maximum dry-matter yield is produced with infrequent clipping to a short height. Clipping when the growth is 8 to 10 inches high or every 3 to 4 weeks seems to provide the best compromise between yield and quality, as yield is only approximately 5 percent less than with clipping when the growth is 14 to 16 inches high.

Root accumulation and stand density may be influenced by management practices. They are important for they reflect the general vigor and potential productivity of the stand and provide protection to the soil. Changes in either root accumulation or stand density may be noted before yields are actually affected by management and thus dictate modifications in practices before irreversible changes develop.

Table 3-9. Forage yield of Coastal bermudagrass with various clipping management treatments, Mt. Pleasant, Texas. 1961-64 averages.[1]

Top growth above clipping ht. (in.)	Clipping height (in.)	Pounds air-dry forage/acre[2]
2-4	2	11,800
	5	10,800
8-10	2	13,800
	5	12,200
14-16	2	15,000
	5	12,200
Clipping height averages	2	13,600
	5	11,800

[1] Holt and Lancaster, 1968.

[2] 240-60-60 fertilizer annually.

Root accumulation changes have been noted in Coastal bermudagrass stands (Table 3-10) in succeeding years following establishment. However, clipping frequency does not seem to be a major factor in influencing root accumulation. Root accumulation is enhanced to some extent by taller stubble heights, but clipping height does not appear to prevent a decline in root accumulation. Thus, while changes in root accumulation occur, neither root accumulation nor the changes are highly sensitive to management practices and do not seem to be related to production. Apparently, root accumulation stabilizes at a satisfactory level for continued production by the stand.

Sod density of Coastal seems to increase with succeeding years (Table 3-11) under a wide range of management practices. Clipping frequency has very little influence on sod density, whereas a shorter sod generally provides a denser cover except possibly with very frequent clipping.

Thus, it seems that Coastal bermudagrass is tolerant to a wide range of management practices in terms of stand maintenance. Frequent clipping reduces yield, but apparently has little if any effect on stand maintenance. Clipping height is much less important in Coastal bermudagrass production than frequency of defoliation. Tall

stubble is not necessary for the maintenance of Coastal bermudagrass and may actually result in slightly reduced yields.

Table 3-10. Weight of Coastal bermudagrass roots with various clipping management practices, Mt. Pleasant, Texas. Three-year summary, 1962-64.[1]

Top growth above clipping ht. (in.)	Clipping height (in.)	Tons roots/acre[2]			
		1962	1963	1964	Average
2-4	2	6.70	4.29	2.06	4.35
	5	6.22	6.01	3.17	5.13
8-10	2	5.33	4.05	2.24	3.87
	5	5.59	4.39	2.68	4.22
14-16	2	5.00	3.74	3.30	4.01
	5	5.64	3.77	3.08	4.16
Average (yr.)		5.74	4.38	2.76	4.29

[1] Holt and Lancaster, 1968.

[2] 240-60-60 fertilizer annually.

Table 3-11. Density of Coastal bermudagrass with various clipping management practices, Mt. Pleasant, Texas. Three-year summary, 1962-64.[1]

Top growth above clipping ht. (in.)	Clipping height (in.)	Number of stems/sq. ft.[2]			
		1962	1963	1964	Average
2-4	2	222	248	268	246
	5	245	359	375	326
8-10	2	198	248	259	235
	5	247	313	300	287
14-16	2	218	204	178	200
	5	273	255	303	277
Average (yr.)		234	272	281	262

[1] Holt and Lancaster, 1968.

[2] 240-60-60 fertilizer annually.

Figure 3-5. Coastal bermudagrass showing growth approximately 18 inches high.

Figure 3-6. Kleingrass

Kleingrass Management

Kleingrass is a relatively recent plant introduction from Africa. It is a bunchgrass which grows to a height of 3 to 4 feet (Figure 3-6). While it has shown a very wide range of adaptation, little was known of its cultural and management requirements until very recent years. Almost all initial plantings were made in rows because of limited seed supplies and high seed costs. Currently most stands are established by either drilling or broadcasting. A five-year study in the Brazos River bottom indicates that solid drill stands produce higher yields than row plantings. However, this does not preclude the practice of establishment of stands in rows followed by subsequent volunteering to a solid stand. This practice has been used successfully in research plantings.

Initially, kleingrass yields may be higher in rows (Table 3-12) than in solid stands. However, after the establishment period, a solid stand is likely to be more productive. During the first five years of this study, a solid stand (Table 3-12) had produced 12 percent more forage than cultivated rows. In both the fourth and fifth years, the increase was 50 percent over rows.

Kleingrass requires appropriate management for sustained production. However, it apparently is less sensitive to defoliation than are the taller bunchgrasses. Yields in a 5-year study have been 70 percent higher with clipping at a 2- to 4-inch height than at a 8- to 10-inch height (Table 3-12). Stands have not changed due to the harvest practices. Growth which was made but left on the plant below the 8- to 10-inch height was of no particular advantage to the plant. These results were obtained with 3 to 4 clippings annually and might be different with considerably more frequent clipping.

Earlier work (McDaniel and Holt, 1963) had shown that highest yields were obtained with the closest and most frequent defoliation (six cuttings annually at a height of 2 to 3 inches). However, crown size and root accumulation were restricted by the treatment, suggesting that continued close defoliation would adversely affect sustained production.

Additional work (Evers and Holt, 1972) has confirmed that kleingrass is respon-

Table 3-12. Kleingrass yields as influenced by method of planting and height of cutting, Texas A&M University Farm near College Station, 1966-70.

Method of planting	Height of clipping (in.)	Pounds dry forage/acre 1966	1967	1968	1969	1970	Average
Row	2-4	6,180	5,700	4,640	4,958	5,000	5,296
	8-10	3,290	3,880	2,710	2,907	2,743	3,106
(Average)		4,725	4,787	3,672	3,933	3,872	4,200
Drill	2-4	4,700	5,640	5,080	7,267	6,992	5,956
	8-10	1,490	3,890	2,980	4,641	4,420	3,484
(Average)		3,090	4,770	4,030	6,004	5,706	4,720
Height of clipping averages:							
	2-4	5,440	5,670	4,860	6,162	5,996	5,626
	8-10	2,390	3,890	2,840	3,774	3,582	3,295

sive to cutting height. Plants clipped to a 6-inch height were more productive in terms of tillers and leaf area than plants clipped at a 2-inch height. Plants clipped at the taller height also had larger crowns containing higher concentrations of carbohydrates which would contribute to maintaining an adequate stand from year to year. These results were obtained under rather short clipping frequencies of 3, 4, and 5 weeks. Clipping frequency had no effect on any of the plant parameters studied.

There are adequate research results and experiences with kleingrass to show that it can be maintained under a wide range of clipping or grazing practices. However, the plant cannot be maintained in a productive state under a defoliation schedule that would permit no growth to develop above a 2- to 3-inch height.

EXAMPLES OF GRASS SEED PRODUCTION AND HARVESTING

Grass seed production and seed harvesting often require specialized "know how" and equipment. Seed maturation, especially in warm-season grasses, may extend over a considerable period, requiring careful timing to harvest maximum yields. The seed are small and often surrounded by appendages which complicate harvesting and seed processing. Not nearly all the problems in grass seed production and harvesting have been

researched. This section presents information only on seed production characteristics of one grass and a specialized grass seed harvester with fairly broad application.

Kleingrass Seed Production

Kleingrass seed yields vary from year to year, depending on cultural treatments, harvest practice and possibly age of stand (Table 3-13). Satisfactory yields are obtained in some years but not in others. Because of seed shattering and indeterminate flowering, many seed are lost prior to harvest and others are immature at the time of harvest. Anthesis (blooming) begins at the top of the inflorescence and on the tips of the branches of the inflorescence and progresses toward the base of the inflorescence. Frequently, shattering may be noted at the extremities of the inflorescence while florets near the base are in anthesis. Not all inflorescences develop at the same time. Thus, some inflorescences may be maturing at the time others are initiating anthesis. Because of these seed-producing characteristics, management and harvest practices are extremely important.

Table 3-13. Seed yield and quality of kleingrass, College Station, 1958-59.

Year	Pounds seed/acre June	August	Total	Percent pure seed June	August	Total
1958	127	74	201	30	35	75
1959	50	60	110	42	11	53

Holt, 1965.

By harvesting seed at 5- to 7-day intervals starting at the time of first seed maturation and continuing for 25 to 30 days (each harvest being made from a different plot), it has been shown that peak yields may be expected if harvest is 5 to 12 days following first seed maturation (Figure 3-7). There seems to be a less definite peak in yield in the fall than in the spring. Apparently, the rate at which seed mature and shatter in the fall approximates the rate at which new inflorescences and seed develop and mature. This has been observed to occur over a period of three weeks or longer. This would suggest that a system of harvest which would remove mature seed by agitation at frequent intervals rather than cutting the plants might result in improv-

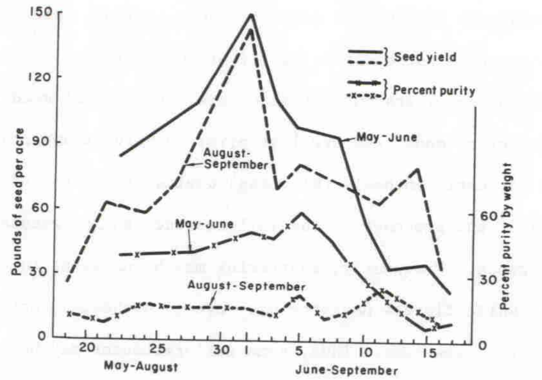

Figure 3-7. The influence of time of harvest on seed yield and purity of kleingrass, 1959. Initial sampling (harvest) was on date of first observed shattering. Holt. 1965.

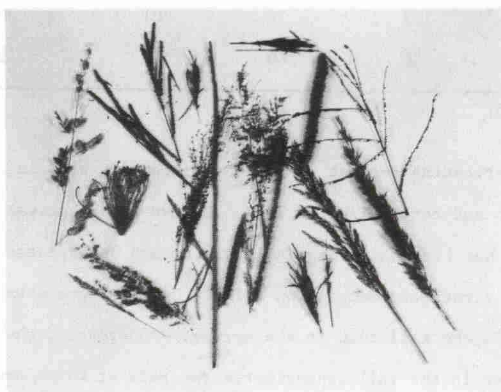

Figure 3-8. Range of grass inflorescence (seed) types and characteristics.

ed yields and quality. Seed quality in the above data from successive harvests was lower than normally would be expected because unthreshed seed heads were collected, dried and then threshed. Immature seed which would not thresh while green would be included after drying.

An alternative method of harvesting seed is reported later in this chapter. The method provides for collecting mature seed without cutting the plants and has been used successfully with kleingrass.

Harvesting Seed of Grasses

Many of the perennial grasses adapted to Texas have seed characteristics or seed production patterns that dictate specialized harvesting techniques. While the conventional combine has been used with varying degrees of success and efficiency, many equipment adaptations and innovations also have been developed and used by individual seed producers. Harvesting equipment and procedures are not and cannot be standardized completely because of the wide range in seed (inflorescence) characteristics (Figure 3-8).

Alterations of regular grain harvest equipment for grass seed harvesting have been described (Hill, et al., 1969, and Hary et al., 1969) recently, along with explanations of the need for such innovations. Hill and co-workers state that "It is possible to harvest most grasses with regular grain harvest equipment, but all methods of harvesting grass seed with regular equipment cause a reduction in seed quality and amount. In the regular type of harvest, the grass is cut at a time selected to give the greatest amount of seed in either the mature or hard dough stage. Usually, this is when the seed in the topmost part of the head are in the mature stage and before they begin to shatter. Material cut with a windrower is left in the field until the seed and stems are dry enough for the seed to be separated from the stems and leaves. Then the material is picked up and threshed with a combine that is properly adjusted to collect and save the highest quality seed. Seed harvested in this manner are dry and keep well, but they may contain some green, shriveled seed with low germination.

"Direct combine harvesting of grass seed may be done if the machine is well adjusted for the task and carefully operated (Cooper, Smith, and Adkins, 1957). Combining is started about the time the seed in the topmost part of the head have started to shatter out. Usually, cutting and combining the upper half of the grass stems at this time yield a greater amount of seed in the mature and hard dough stage than at any other stage of maturity. The seed material obtained from the combine must be handled carefully because it will contain a substantial amount of green seed material. This green seed and other green material harvested with the more mature seed must be dried before the seed will keep satisfactorily. After the material is dried, the resultant seed will probably be of lower quality than those obtained with the windrower and pickup combine.

Harvest Procedures

"Best quality seed are obtained when the harvest process is designed to obtain only those seed in the mature or hard-dough stage. Although this harvest procedure requires successive harvests of the same seed stalks, the resultant amount and quality of grass seed is worth the effort. Requirements for such a grass seed harvest process to follow.

1. The grass stem with the head must be left standing with as little injury as possible after the mature seed are removed.
2. Only the mature seed and some seed in the hard-dough stage should be removed, leaving the younger seed.
3. Harvested seed material should be of high quality and should keep satisfactorily with no more attention than loose sacking with air space between the sacks.

"Windrowers and grain combines have been modified to harvest the ripe seed and to leave the green seed on the grass stem to be harvested later.

"Sickles and guards of the windrowers are covered so that they will not cut or snag the grass, and the speeded-up reel knocks the ripe seed onto the canvases. The canvases in turn deliver the seed to a pan attached to the center of the windrower. Conversion of a combine is essentially the same as that of a windrower except that the steel bottom of the header is used to catch the seed.

"Kleingrass, indiangrass, Higgins buffelgrass, Bell rhodesgrass, birdwoodgrass,

and King Ranch bluestem have been harvested successfully with the modified windrower and combine."

SUMMARY

Successful establishment of forage species requires careful attention to seedbed preparation; time, depth, and rate of planting; weed control; and fertilization. These factors are even more important for small-seeded perennial grasses and legumes than for field crops. Precision planting equipment to control both seeding rate and seeding depth is highly desirable. In order to emerge, the seed must be placed near the surface, which is impossible if the seedbed is poorly prepared. The individual factors will vary in importance, depending on the species, soil type, and season in which planted.

Successful management of a forage species is dependent on a knowledge of its growth cycle, response to defoliation, and fertility requirements. Many of the forage species, because they were developed for use under grazing, have a wide tolerance to defoliation practices. However, other species have to be managed carefully for sustained high production. Similar-type responses are noted to fertility requirement of forage species. Even if a species will survive at a low fertility, its potential is not being realized if only a fraction of the needed fertilizer is being used.

Grass seed production is a specialized field because of the many different seed and seed production characteristics encountered among the grasses and legumes. These varying characteristics require adaptations in harvest practices and harvesting equipment.

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