Stimulating Existing Grass Stands For Seed Production

Mark E. Majerus
USDA-SCS Plant Materials Center
Bridger, Montana

The seed of many conservation and forage plants has come into great demand because of the recent enactment of the Conservation Reserve Program (CRP). Seed supplies were already low, resulting from recent drought years in the Northern Great Plains region. This revitalized market for seed has encouraged many producers to try to prolong seed production on existing seed fields or to rejuvenate older pastures and rangeland for seed production. Perennial grasses show a characteristic decline in seed production with age of stand regardless of the conditions under which they grow. Most grasses produce little or no seed the first growing season, reaching a peak seed yield in the second or third season, and gradually declining as the stand ages.

Morphology and Physiology

How long a plant is able to maintain seed production at an acceptable economic level is dependent on numerous environmental conditions and management practices. Before any management decisions can be made, a grower must understand the morphology and physiology of the plant with which they are working. Flowering in perennial grasses involves three stages: induction, initiation, and development. Most investigators agree that in cool-season grasses, floral induction of the vegetative primordia generally occurs in the fall, the induced meristem remaining in a vegetative condition throughout the winter [Sass and Skogman (1951), Gardner and Loomis (1953), Evans (1964), Hodgson (1966), Newell (1951), and Canode et al. (1972)]. A shortened photoperiod and/or low temperatures are usually required by cool-season grasses to stimulate induction. Induction is considered a chemical or hormonal differentiation involving no morphological alteration of the vegetative apex. The transition from vegetative to reproductive growth phase is first indicated by an elongation of the primordial axis followed by lateral branch development. This transformation generally occurs early in the spring when increasing temperatures and lengthening photoperiods occur. Newell (1951) in Nebraska found that smooth brome (Bromus inermis Leyss.) transplanted in August from field conditions to the greenhouse with long photoperiods produced vigorous foliage growth without any panicle production. Delaying removal of plants from the field until 15 September resulted in a threshold of floral induction. Leaving plants in the field until 15 November resulted in an increase in the number of panicles-per-plant, and exposure up to 15 December did not result in additional panicle production. Therefore, the seed head primordia had been induced by 15 November. Canode et al. (1972), working with Kentucky bluegrass (Poa pratensis L.), orchardgrass (Dactylis glomerata L.), smooth bromegrass, and crested wheatgrass (Agropyron *desertorum Fisch*. ex Link), found the following timetables for induction, initiation, and development:

Table 1. Initiation and development of floral primordia of some cool-season grasses at Pullman, Washington (Canode et al. 1972).

Species & Cultivars	Inflorescence Induction	Internode Initiation	Elongation
Kentucky bluegrass			
Deita	Nov. 1	Jan. 22	Mar. 5
Newport	Dec. 1	Feb. 5	Mar. 26
Merion	Jan . 1	Feb. 26	Apr. 9
Cougar	Jan. 1	Feb. 12	Apr. 9
Orchardgrass			
Latar	Jan. 1	Feb. 19	Mar. 26
Smooth Bromegrass			
Manchar	Oct. 15	Feb. 12	Mar. 19
Crested Wheatgrass			
Nordan	Nov. 1	Feb. 19	Apr. 9

Lawrence and Ashford (1964), studying Russian wildrye *[Psathyrostachys juncea (Fisch.*) Nevski], found that all shoot primordia examined from 24 July to 7 August were found to be in the vegetative stage. From 14 August to 4 September, 5% of the apices were starting to elongate. By 30 October all growth stages from vegetative to the advanced bud were found, and 80% of all apices were in some phase of transition to the floral stage. However, shoot apices of reed canarygrass (Phalaris *arundinacea L.*), bromegrass, intermediate wheatgrass [Elytrigia *intermedia (Host)* Nevski], and Altai wildrye [Leymus angustus (Trin.) Pilger] showed only vegetative forms on 30 October, but made the transition in early spring. Hodgson (1966) found that induction, initiation, and partial floral development in autumn appear to be normal behavior for the majority of **Alaskan** grasses and those of similar northern regions. Some northern grasses went as far as producing anthers in the fall.

The seed crop a grower will get next year is already developing the previous fall. The care and management a seed field receives in late summer and fall actually can have more bearing on seed yields and stand longevity than treatment in the spring and summer prior to seed harvest. **Seed yields and stand** longevity can be strongly correlated with how some of the cultural and management techniques are applied to seed fields during this critical fall period, e.g., cultivation, aftermath removal, fertilization, and maintaining adequate soil moisture.

Cultivation

Attempts to mechanically manipulate the reproductive potential of grasses have resulted in the stimulation of young tissue growth by providing space or removing competition of old growth. Crowle and Knowles (1962) have shown that solid, sodbound stands of smooth bromegrass can produce adequate seed yields with shallow fall plowing, disking, and packing every 4 years. Four-year-old stands of 'Shoshone' beardless wildrye [Leymus triticoides (Buckley) Pilger] have been disked, packed, and irrigated in the fall to rejuvenate stands at the Bridger, Montana Plant Materials Center (PMC).

Stroh (1971) evaluated a walking row method of cultivation in an attempt to maintain young plants for seed production. Western wheatgrass [Pascopyrum smithii (Rydb.) A. Love] was seeded in 91-cm rows and allowed to establish. After the first seed crop was removed, the original rows were removed by rototilling, and rhizomes between rows became the row for the following year's seed crop. This continued for three years.

Allowing the stand of western wheatgrass to become solid produced as much seed over the 4-year period (average of 419 kg/ha) as the walking row (405 kg/ha), and at less cost. The walking row maintained the plants in a physiologically young and vigorous condition, but weed invasion (primarily downy brome Bromus tectorum L.) and higher production costs made this method impractical. Canode (1965) mechanically removed 50% of the stand of intermediate wheatgrass grown in 91-cm rows, increasing seed yields 32% over a 4-year period, and the characteristic decline with age was reduced. A similar study in which rows of orchardgrass and Kentucky bluegrass were gapped resulted in no significant seed-yield increases (Canode 1972). Lambert (1964) also showed that timothy (Phleum pratense L.) and meadow fescue (Festuca elatior L.) did not respond to gapping. Chemical thinning of intermediate wheatgrass stands with Amitrol"M reduced yields in the year of application, but equaled mechanical thinning the next 2 years (Canode 1965). In Denmark, thinning timothy with RoundupT111 and mechanically thinning decreased lodging, increased seed yields, and increased seed size (Skuterud 1986).

It has been frequently shown that most forage grasses produce more seed for a longer period of time if maintained in rows rather than solid stands [Black and Reitz (1969), Dodds et al. (1987), Holzworth and Wiesner (1986), Klages and Stark (1949), Cornelius (1950), and Lawrence (1980)]. At the Bridger PMC 'Garrison' creeping foxtail (Alopecurus arundinaceus Poir.), 'Rosana' western wheatgrass, and 'Shoshone' beardless wildrye are initially seeded in 91-cm rows, but allowed to form solid stands for maximum seed production. All other species are maintained in rows.

Grass stands, even in rows, generally become "sodbound" with age, producing only a few strong rhizomes or tillers in the center of the row, Most of the new primordia are initiated near the outer edge of the row. The continued and untimely removal of the outer edge of the row can cause a reduction in seed yield and longevity that might be associated with age of stand (Canode 1965). Cultivation should be shallow (4-5 cm) to avoid pruning of fibrous roots. Cultivation should not remove green, vegetative growth from the margins, as this is a portion of the eventual seed head primordia. Close cultivation, if necessary to maintain a species within a row. should be done early after harvest, before the initiation of new growth. Close cultivation late in the fall after the initiation of fall growth and in early spring can severely damage potential seed production. Canode (1972), using standard cultivation equipment on 'Newport' Kentucky bluegrass, compared minimum tillage with a rotary hoe in April to close and wide tillage with a cultivator in September and April (Table 2). Close cultivation significantly reduced seed yields. Cultivation in early fall down the row with a rotary hoe or triple-K type, spring-tooth harrow will remove decadent material from within established rows, allowing for more floral development in the center of wide, older rows.

Table 2. Influence of time and method of cultivation on seed production of three continuous crops of Newport Kentucky bluegrass (Canode 1972).

Cultivation*

Time	Method	Seed Crop 2nd	3rd	4th	Average
				Seed (kg/ha)	
April	Minimum	91 6a	291 ab	982a	730a
September	Wide	856a	337a	853 bc	682 b
April	Wide	803a	233 b	808 c	635 c
September	Close	766 b	353a	753 c	624 c
April	Close	642 c	320a	768 c	577 d
CV (%)		13	26	15	9

* All plots received minimum cultivation with a rotary hoe in April. Wide cultivation left a 46-cm and close cultivation left a 30-cm undisturbed row.
~Means followed by the same letter are not significantly different at the .05 level of probability.

Aftermath Removal

The vigor of the rows and the amount of decadence within the row can be greatly controlled by aftermath removal. Aftermath can be removed in three basic ways: mechanical removal (mowing, baling, raking, etc.), burning, or grazing. Each species reacts somewhat differently to each of these removal techniques, so a blanket recommendation cannot be made. Post-harvest residue burning in the production of grass seed originated in the Pacific Northwest for disease control about 40 years ago (Hardison 1976). In western Oregon and in parts of the Palouse region, burning has been adapted as a universal practice for many cool-season grasses. In the intermountain and northern Great Plains region, where diseases are not a severe problem, burning for aftermath removal has produced variable results. In Montana and Wyoming, very little burning is used, especially on bunchgrassses. 'Whitmar' beardless wheatgrass has been severely damaged with fall burning, and Altai wildrye and 'Garrison' creeping foxtail were damaged when accidentally burned in early spring. At the Bridger PMC, only 'Goshen' prairie sandreed (Calamovilfa longifolia (Hook.) Scribnj, a warm-season grass, is burned in late fall or early spring.

Knowles (1966) in Saskatchewan showed that both burning and mechanical aftermath removal was better than no removal on smooth bromegrass. This difference in seed yield was attributed, in part, to the control of leaf spot by removing aftermath. Canode and Law (1978) show significant yield increases with burning compared to mechanical straw removal and mechanical straw and stubble removal (Table 3) at Pullman, Washington. The burning was done after seed harvest, ranging from 15 August to 1 September. In northeast Oregon, Pumphrey (1965) found that early burning and complete mechanical aftermath removal produced consistently higher seed yields (Table 4). New growth was destroyed by late burning, resulting in fewer particles being formed the next year. This shows how critical fall management is on the next year's seed production. Open burning of residue causes a loss of nitrogen (N) and sulfur (S), bur leaves phosphorus (P) and potassium (K) in the ash in a form that may be more readily available than P and K left in the organic matter remaining after mechanical removal or residue. Fulkerson (1980) found that in Ontario, seed yields of timothy were not affected by aftermath removal, but orchardgrass seed production was significantly increased by fall stubble removal to a 40-cm height. This agrees with Rampton and Jackson (1969), who suggested that removal should be carried out as soon after seed harvest as possible. Lawrence (1973) found that clipping each fall nearly doubled seed production of Altai wildrye in Saskatchewan.

Table 3. Influence of post-harvest residue management on the seed yield of three grass species (Canode and Law 1978).

<u>Seed Crop and Year Harvested</u>

Species & Residue Management	Second (1973)	Third (1974)	Fourth (1975)	Fifth (1976)	Average
	Seed Yield (kg/ha)*				
Red fescue					
Burned	582 a	691 a			636 A
Removed (SSR)-	502 a	576 b			539 B
Removed straw	499 a	420 c			459 C
Smooth bromegrass					
Burned	896 a	1,614 a	787 a	1,191 a	1,122 A
Removed (SSR)	829 a	1,242 b	664 b	922 a	914 B
Removed straw	808 a	1,049 c	648 b	888 b	848 C
Crested wheatgrass					
Burned	687 a	1,209 a	692 a	899 a	872 A
Removed (SSR)	635 a	1,128 a	661 a	439 c	716 C
Removed straw	610 a	1,201 a	710 a	640 b	790 B

Means in each column for each species not followed by the same letter are not significantly different at the .05 level of probability based on Duncan's Multiple range Test. Each mean is an average for three fertility rates and five replications.

~ Straw and Stubble Removed.

Table 4. Residue management affect on seed yield of Kentucky bluegrass and red fescue (Pumphrey 1965).

Residue Management	Bluegrass Exp. 103-62	Bluegrass Exp. 104-63	Bluegrass Exp. 101-64	Red Fescue Exp. 101-63	Red Fescue Exp. 103-63	Red Fescue Exp. 102-64	Red Fescue Exp. 104-64
	Seed Yield (lb/acre)*						
Burned, late Aug.	337 a	475 a	302 a	765 a	335a	766 a	388 a
Sept.	278 b	478 a	230 b	731 b	310b	506 b	318 b
Oct.	169 c .	388 b	170 c	674 c	83c	194 c	69 e
Complete mechanical removal	-	460 a	293 a	743 ab	345a	760 a	307 b
Straw baled	-	364 c	228 b	631 d	-	558 b	249 c
No removal	186 c	-	181 c:	-	88c	507 b	198 d

Numbers followed by the same letter in each column are not significantly different at the .05 level of probability.

Lawrence and Ashford (1964a, 1964b), working with Russian wildrye, established that removal of aftermath by grazing with sheep increased seed yields by preventing the development of long mesocotyls, which elevated the shoot apices to a height where they were subjected to frost damage. Mesocotyls sampled from grazed plants averaged 10 mm, while tillers from ungrazed plants had an average mesocotyl length of 45 mm. Frost damage occurred on tillers showing mesocotyl lengths from 40 to 60 mm. Lawrence and Lodge (1974) grazed aftrermath of Russian wildrye, Altai wildrye and green needlegrass, resulting in increased seed yields in subsequent years for all three species. Many cool-season grasses grown for seed can be used as fall or early winter pasture. This type of management may be particularly important in growing seed of a low seed-producing species because it provides the seed grower additional income. However, Lawrence and Ashford (1964b) found that the time of grazing is critical in Russian wildrye because of its early floral primordia initiation (Figure 1). Growers in the Powell, Wyoming area are successfully grazing seed field aftermath with shetland ponies, cattle, and sheep. Grazing and aftermath removal are generally restricted to fall, but Steiner and Grabe

(1986) found that grazing subterranean clover (Trifolium *subterraneum L.)'in* Oregon with sheep to reduce the amount of top growth, resulted in significant increases in seed production.

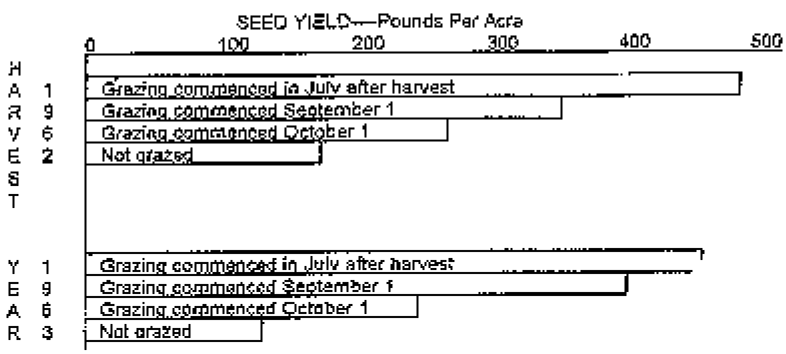

Figure 1. Seed yields of Russian wildrye as influenced by grazing (Lawrence & Ashford 1.964b).

Fertilization

Fertilization can increase seed production in almost any plant grown for seed. Fertilization of cool-season grasses is best done in late summer or fall (Smika and Newell 1966, Dodds et al. 1937, Lawrence and Kilcher 1964). Stroh et al. (1978) found that economical seed production could continue on stands of 'Garrison' creeping foxtail by increasing fertilizer rates. After 5 years of annual applications of 67 kg/ha, seed production dropped off. Annual applications were increased to 112 kg/h1a, resulting in 5 more years of production.. At the Bridger RMC, seed production of 'Shoshone' beardless wildrye was significantly increased with each 50 kg/ha of N added (Figure 2), but the pattern of peak production the second year, with rapidly declining production thereafter, was the same for all fertility levels (Majerus 1987).

Figure 2. The response of seed production of beardless wildrye to annual applications of four rates of nitrogen fertilizer. All production figures are an average of five accessions.

Smika and Newell (1966), working with western wheatgrass, and Newell (1951), using smooth bromegrass, showed that good fertility in the fall and early spring increased the number of panicles, resulting in increased seed production. In cool-season grasses, the number of panicles is generally determined in the fall and the number of seeds-per-panicle is dependent on the vigor of the plant in early spring (Smika and Newell 1966). This supports Lawrence and Kilcher (1964) and Dodds et al. (1987) in their suggestions that fertilizer application be split, with the majority being applied in the ' fall. Fertilized stands generally sustain higher seed production levels than unfertilized, but do not necessarily extend the longevity of the stand much more than a year or two.

Soil Moisture

Soil moisture conditions are also critical for optimum seed production, but the grower does not always have total control except under irrigated conditions. Smika and Newell (1966) concluded that on western wheatgrass, best seed production resulted from irrigating with sufficient water to fill the root zone in either the fall or early spring and again when the grass is in "boot". At the Bridger PMC, it has been found that if natural precipitation does not come in late September or early October, all stands must be irrigated prior to freeze-up. Under dryland conditions, if late summer and fall moisture is poor, seed production may likely be poor the following year.

Conclusion

Seed production is influenced by a variety of environmental and management conditions-each species reacting uniquely. Aftermath removal, fertilization, cultivation, and irrigation in the fall as soon as possible after seed harvest is critical in maintaining maximum production of cool-season grasses. The longevity of a productive seed production field is increased by proper management, to a point. At some age, usually 4 to 5 years for most coolseason grasses, stand density, plant vigor, and weed infestation, etc. make a field uneconomical to maintain. Plowing out old fields and establishing new ones is usually more economical than trying to stimulate old, decadent, weedy fields.

Literature Cited

1. Black, A. L., and L. L. Reitz. 1969. Row spacing and fertilization influences on forage and seed yields of intermediate wheatgrass, Russian wildrye, and green needlegrass on dryland. Agron. J. 16:801-805.

2. Canode, C. L. 1965. Influence of cultural treatments on seed production of intermediate wheatgass [Agropyron *intermedium* (Host) Beauv.]. Agron. J. 57:107-210.

3. Canode, C. L. 1972. Grass seed production as influenced by cultivation, gapping, and post harvest residue management. Agron. J. 64:148-151.

4. Canode, C. L., M. Anwar Maun, and 1. D. Teare. 1972. Initiation of inflorescences in cool season perennial grass. Crop Sci. 12:19-22.

5. Canode, C. L., and A. G. Law. 1978. Influence of fertilization and residue management on grass seed production. Agron J. 70:543-546.

6. Cornelius, D. R. 1950. Seed production of native grasses under cultivation in eastern Kansas. Ecological Monographs 20:1-29.

7. Crowle, W. L., and R. P. Knowles. 1962. Management of bromegrass for seed in central Saskatchewan. Canada Dept. Agric. Pub. 1148.

8. Dodds, D., J. Carter, D. Meyer, and R. Haas. 1987. grass seed production in North Dakota. Coop. Ext. Serv., Fargo, ND. Pub. 14, AGR-7, R-917.

9. Evans, L. T. 1964. Reproduction. p.126-153. *In C.* Barnard (ed.) Grasses and Grasslands. McMillan Press, London.

10. Fulkerson, R. S. 1980. Seed yield response of three grasses to post-harvest stubble removal. Can. J. Plant Sci. 60:841-846.

11. Gardner, F. P., and W. E. Loomis. 1953. Floral induction and development in orchardgrass. Plant Physiol. 28:201-217.

12. Hardison, J. R. 1976. Fire and flame for plant disease control. Ann. Rev. Phytopathology 14:355-379.

13. Hodgson, H. J. 1966. Floral initiation in Alaska gramineae. Sot. Gaz. 127:64-70.

14. Holzworth, L. K., and Wiesner. 1986. Grass and legume seed production in Montana and Wyoming. Mont. and Wyo. Soil Conserv. Dist., Bridger, Mont. Special Report No. 12.

15. Klages, K. H. W., and R. H. Stark. 1949. Grass and grass seed production. U. of Idaho Agric. Exp. Stn. Bull. 273.

16. Knowles, R. P. 1966. Effect of stubble removal on seed production of bromegrass. Agron. J. 58:556-557.

17. Lambert, D. A. 1964. The influence of density and nitrogen in seed production stands of S.48 timothy (Phleum pratense L.) and S.215 meadow fescue (Festuca pratensis L.). J. Agr. Sci. 63:35-42.

18. Lawrence, T. 1973. Seed yield of Altai wild ryegrasses influenced by aftermath removal, Can. J. Plant Sci. 53:545-546.

19. Lawrence, T. 1980. Seed yield of Altai wild ryegrass as influenced by row spacing and fetlizer. Can. J. Plant Sci. 60:249-253.

20. Lawrence, T., and R. Ashford. 1964a. Mesocotyl development in Russian wild ryegrass and its effect on survival of shoot apices. Nature 201(4920):727-728.

21. Lawrence, T., and R. Ashford. 1964b. Seed yield and morphological development of Russian wild ryegrass as influenced by grazing. Can. J. Plant Sci. 44:311-317.

22. Lawrence, T., and M. R. Kilcher. 1964. Effect of time of fertilizer application on the seed and forage yield of Russian wild ryegrass. J. Range Management 17:272-273.

23. Lawrence, T., and R. W. Lodge. 1974. Grazing seed field aftermath of Russian wild ryegrass, Altai wild ryegrass, and green needlegrass. Can. J. Plant Sci. 55:397-406.

24. Majerus, M. E. 1987. Effect of nitrogen fertilization on beardless wildrye [Leymus trificoides (Buckley) Pilger] growing in wet-saline soils. (submitted for publication)

25. Newell, L. C. 1951. Controlled life cycles of bromegrass (Bromus inermis Leyss.) used in improvement. Agron. J. 43:417-424.

26. Pumphrey, F. V. 1965. Residue management in Kentucky bluegrass (Poa pratensis L.) and red fescue (Festuca rubra L.) seed fields. Agron J. 57:559-561.

27. Rampton, H. H., and T. L. Jackson. 1969. Orchardgrass seed production in western Oregon. Oregon Agric. Exp. Stn. Tech. Bull. 108.

28. Sass, J. E., and J. Skogman. 1951. The initiation of the inflorescence in (Bromus inermis Leyss.). Iowa State J. Sci. 25:513-519.

29. Skuterud, R. 1986. Thinning of grasses for seed production with glyphosate applied by rope wick. FORSK FORS LANDBRUKET 37(4):231-240.

30. Smika, D. E., and L. C. Newell. 1966. Cultural practices for seed production from established stands of western wheatgrass. Univ. of Nebraska Agric. Exp. Stn. Res. Bull. 223.

31. Stark, R. H., A. L. Hafenrichter, and K. H. Klages. 1949. The production of seed and forage of mountain brome as influenced by nitrogen and age of stand. Agron. J. 41:508-512.

32. Steiner, J. J., and D. F. Grabe. 1986. Sheep grazing effects on subterranean clover development and seed production in western Oregon. Crop Sci. 26:367-372.

33. Stroh, J. R. 1971. Walking row method of tillage for seed production of western wheatgrass (Agropyron smithii Ryclb.). Agron. J. 63:911-913.

34. Stroh, J. R., J. L. McWilliams, and A. A. Thornburg. 1978. Agric. SCS-TP-156.