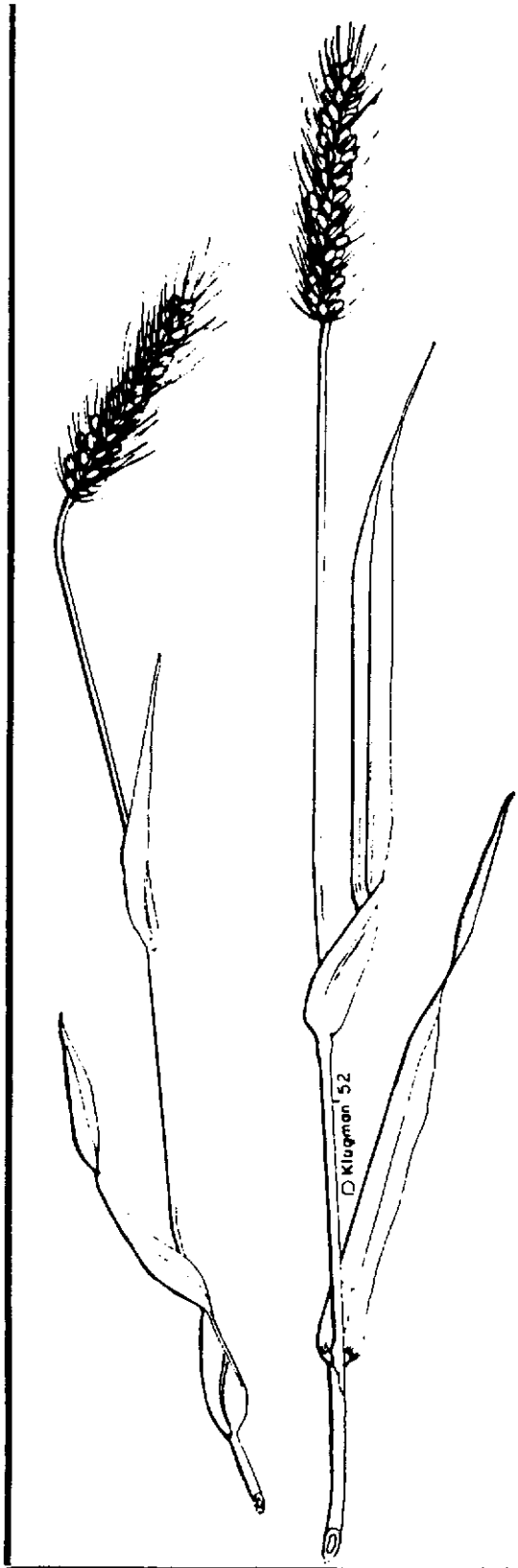
BULLETIN 369
JUNE 1963

LIFE HISTORY STUDIES AS RELATED TO WEED CONTROL IN THE NORTHEAST



2 -- Yellow Foxtail and Giant Foxtail

Northeast Regional Publication

Agricultural Experiment Station
University of Rhode Island

AUTHORS

Connecticut ..... R. A. Peters

Maryland ..... J. A. Meade

Maryland ..... P. W. Santelmann

COOPERATING AGENCIES AND PERSONNEL

Northeastern Agricultural Experiment Stations:

Connecticut (Storrs) ..... R. A. Peters, H. C. Yokum
Delaware ..... E. M. Rahn, O. M. Bundy, W. F. Donnalley
Maryland ..... P. W. Santelmann, J. A. Meade, N. C. Glaze
Massachusetts ..... W. H. Lachman, J. W. Durfee, W. C. Lincoln, Jr.
New Hampshire ..... S. Dunn, G. Williams
New Jersey ..... W. F. Meggitt, R. D. Ilnicki, T. F. Tisdell
New York, Cornell, Agronomy ..... S. N. Fertig, M. Alexander, A. D. Rovira P. Hirsch, K. Burger, I. C. MacRae
New York, Cornell, Vegetable Crops ..... R. D. Sweet
Pennsylvania ..... S. M. Raleigh, C. W. LeFevre, C. O. Clagett
Rhode Island ..... R. S. Bell, T. E. Odland, E. Larssen
Vermont ..... T. R. Flanagan, T. Ming, A. R. Langille
West Virginia ..... C. Veatch, C. H. Bear, M. D. Welch, W. P. Pennell

United States Department of Agriculture:

Cooperative State Experiment Station Service, A. J. Loustalot
Crops Research Division, A.R.S., L. L. Danielson, W. C. Shaw

Cover picture courtesy Bulletin 505, Ontario Department of Agriculture.

*Contribution No. 1076 of Rhode Island Agricultural Experiment Station.

WPCO-4M-5-64

TABLE OF CONTENTS

LIFE HISTORY STUDIES AS RELATED TO WEED CONTROL IN THE NORTHEAST*

2—Yellow Foxtail and Giant Foxtail

INTRODUCTION

While some foxtail species are important agronomic plants, several are weeds. Yellow foxtail, *Setaria lutescens,* and green foxtail, *S. viridis,* are common weeds of newly seeded areas in the humid eastern United States. Giant foxtail, S. *faberii,* has become a threat in recent years particularly in the Corn Belt.

Although these summer annual species are common associates of both cultivated and forage crops, relatively little is known regarding their growth characteristics. Such information is needed to further our understanding of the biology and ecology of these weeds to permit a more intelligent approach of their mechanical and chemical control.

This bulletin presents the results of a cooperative study of yellow and giant foxtail performed by the Storrs (Connecticut) and Maryland Agricultural Experiment Stations as part of the NE-42 Cooperative Regional Research Project.

LITERATURE REVIEW

Several of the foxtails are considered to be weeds in the United States. A recent addition to the list is giant foxtail. It was first reported in 1936 in Northern Virginia (2) and from this area has spread rapidly to become prevalent throughout the eastern half of the United States (8, 9, 24, 25, 30). It was reported in Iowa in 1949 and has become one of the most vigorous and common weeds of the state (24). Giant foxtail resembles green foxtail but is larger in all of its parts.

Dormancy in Setaria seeds is recognized (1) but little information is available as to causes or means of breaking the dormancy.

The effect of depth of planting on emergence of yellow and green foxtail was studied by Dawson and Bruns (5). Germination and emergence of green and yellow foxtail from as deep as 5 inches in fine sandy loam was reported. In the field few seedlings developed from seeds on the soil surface. In general, emergence was best from depths of $\frac{1}{2}$ to 1 inch. Emergence decreased with increased depth of planting. Giant foxtail has been reported to emerge from as deep as 5 inches (18).

Among the members of the genus *Setaria,* Hubbard (13) reported many

varieties of S. *viridis* (L.) and S. *italica* (L.) Beauv. He called S. *viridis* an extremely variable species and described two varieties—*ambigua* and *Wernmanni*. In addition he reported (15) many varieties and forms of *S. barbata* (Lam.) Kunth. Gleason (11) lists three varieties of *S. viridis*, differing primarily in bristle characteristics and growth habit. Hitchcock (12) notes variability in S. *macrostachya* H. B. K., and Fernald (10) in S. *verticillata* (L.) Beauv.

Staniforth (26) and Staniforth and Weber (28) investigated the effects of yellow foxtail on the growth and yield of soybeans under four conditions of controlled soil moisture. There was little reduction in soybean yields if moisture was adequate or limiting over the whole season or when it was limiting to the end of July (time of pod development) and then adequate to bean maturity. When soil moisture was adequate until July and then limiting the rest of the season, yields of beans were reduced up to 15%. Knake and Slife (19) also found competition to be greater in years of high rainfall than in years of low June-July rainfall.

The effect of density of foxtail stand on yield has been studied by Weber and Staniforth (29) in soybeans using yellow foxtail and by Knake and Slife (19) in soybeans using giant foxtail. The former found increased foxtail growth and bean yield reduction with soybean stands of less than 9 to 11 plants per foot of row. The latter found a continuous decrease in corn yields as the foxtail spacing decreased from 24 inches to 1 inch.

Nieto and Staniforth (23) investigated the competition between corn and yellow foxtail at three nitrogen levels. They concluded that on Iowa soils low in nitrogen, the application of nitrogen fertilizer would be more profitable than the use of costly herbicides to control weeds. Staniforth (27) has found corn yield reductions as high as 50 per cent with late season hybrids showing a greater reduction than early season hybrids.

Growth reduction of crop plants from an inhibitor produced by other plants has been reported by several workers (3, 4, 7, 20, 21, 22). In most of these investigations a bio-assay method was utilized using filter paper containing the inhibitor solution as a germinating substrate in a petri dish. Evanari (7) by methods of dilution, preparation of solutions isotonic to the natural one, and neutralization has shown that factors other than osmotic pressure and pH are involved in inhibition.

SEED GERMINATION

Procedure

Seed for the germination experiments was collected in the field in the fall of 1958, 1959 and 1960 at the time shattering normally occurs. Periodic attempts were made following harvest to induce germination through altering

the environment or through treatment of the seed by chemical or physical means. Germination was measured by placing 50 seeds on filter paper in a petri-dish placed in a germinator at 80°F.

Results and Discussion

Yellow Foxtail

Seed collected at the time it shattered from the plant in late summer failed to germinate. This post-harvest dormancy continued for several months. This is an important characteristic from a survival standpoint. Temperature and moisture conditions are favorable for germination in late summer and early fall. Any warm season annual such as foxtail would not survive long enough to complete its life cycle if it germinated at this late date.

The time period required for after-ripening of seed stored dry at room temperatures varied between seed lots collected in different years. In Connecticut 5% germination of 1958 seed was obtained by December 1, 1958, by mid-November for 1960 seed but not until the following February 1 for 1959 seed. There was only a very limited further increase in percent germination as long as the seed was stored dry.

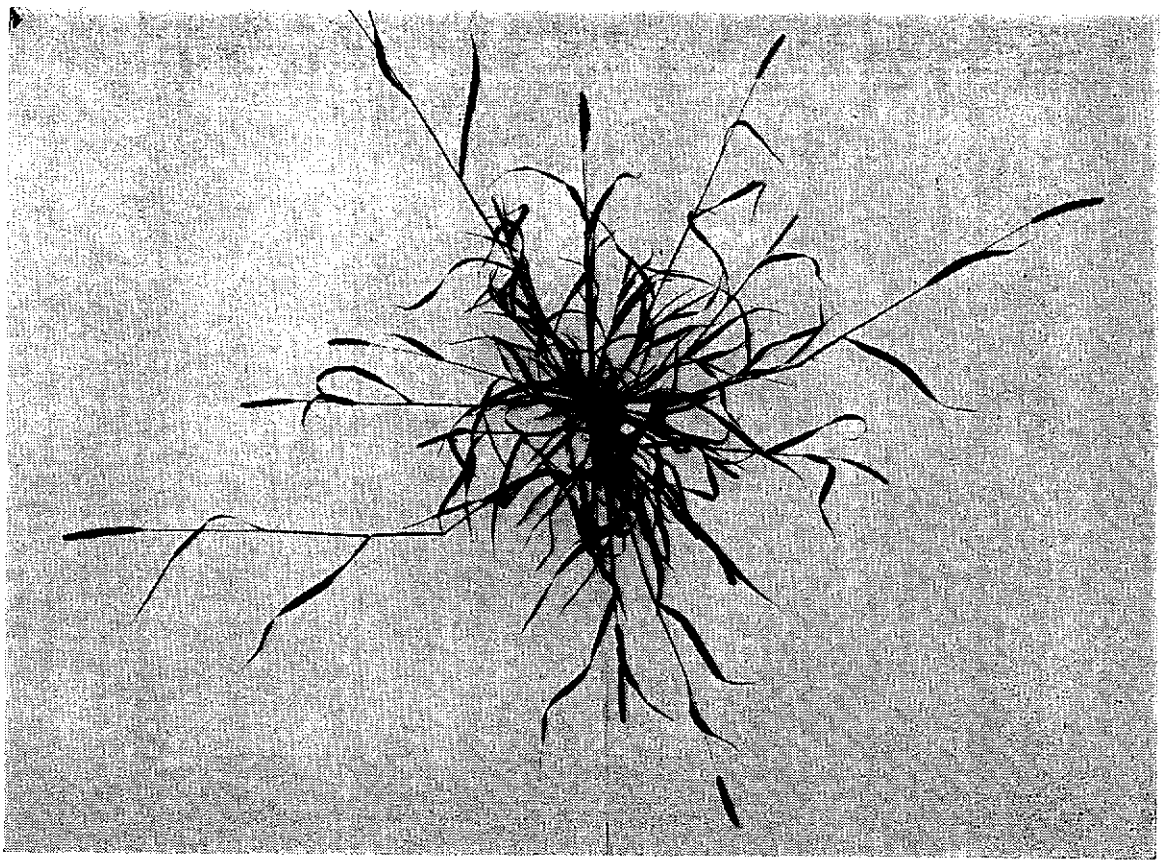


Figure 1 — Typical yellow foxtail plant

Since seed held dry in the laboratory was in an environment unlike that found in the field, the influence of a range of environments was determined. Moisture appeared to be the most important variable influencing germination in an experiment during which samples were withdrawn at 12 different dates from September 28, 1959 to February 26, 1960. The only treatments giving a significant increase in germination were the treatments in which the seed was continuously exposed to moist conditions.

Continuous exposure to cold moist or alternate cold, warm moist conditions was effective in promoting germination. The most effective treatment was the burial of seed in soil in the fall. This subjected the seed to alternate thawing and freezing in addition to continuous moisture.

Attempts to increase germination by soaking in water for 12 hours prior to placing in the germinator gave negative results. There was no significant

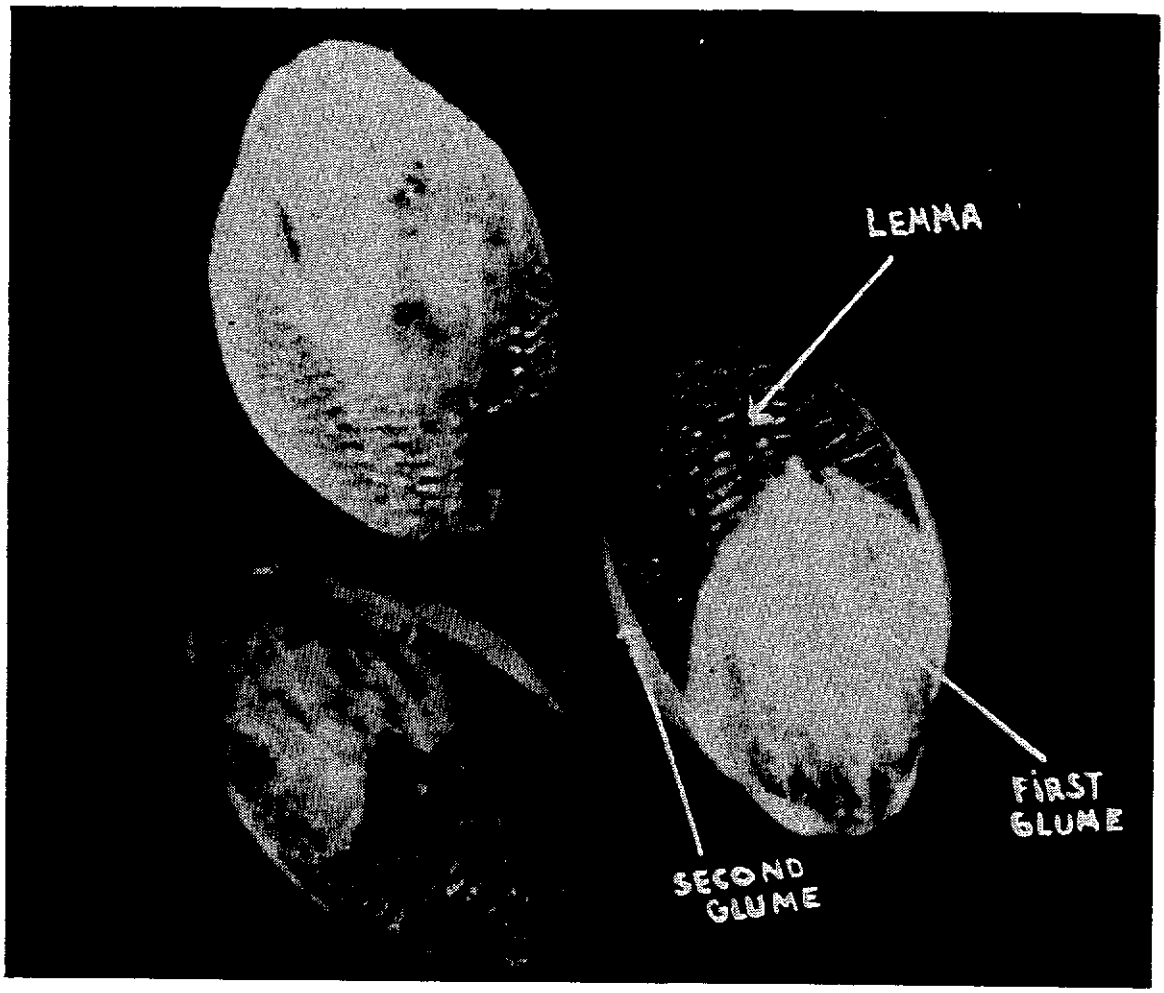


Figure 2—Yellow foxtail seed showing first and second glumes and lemma.

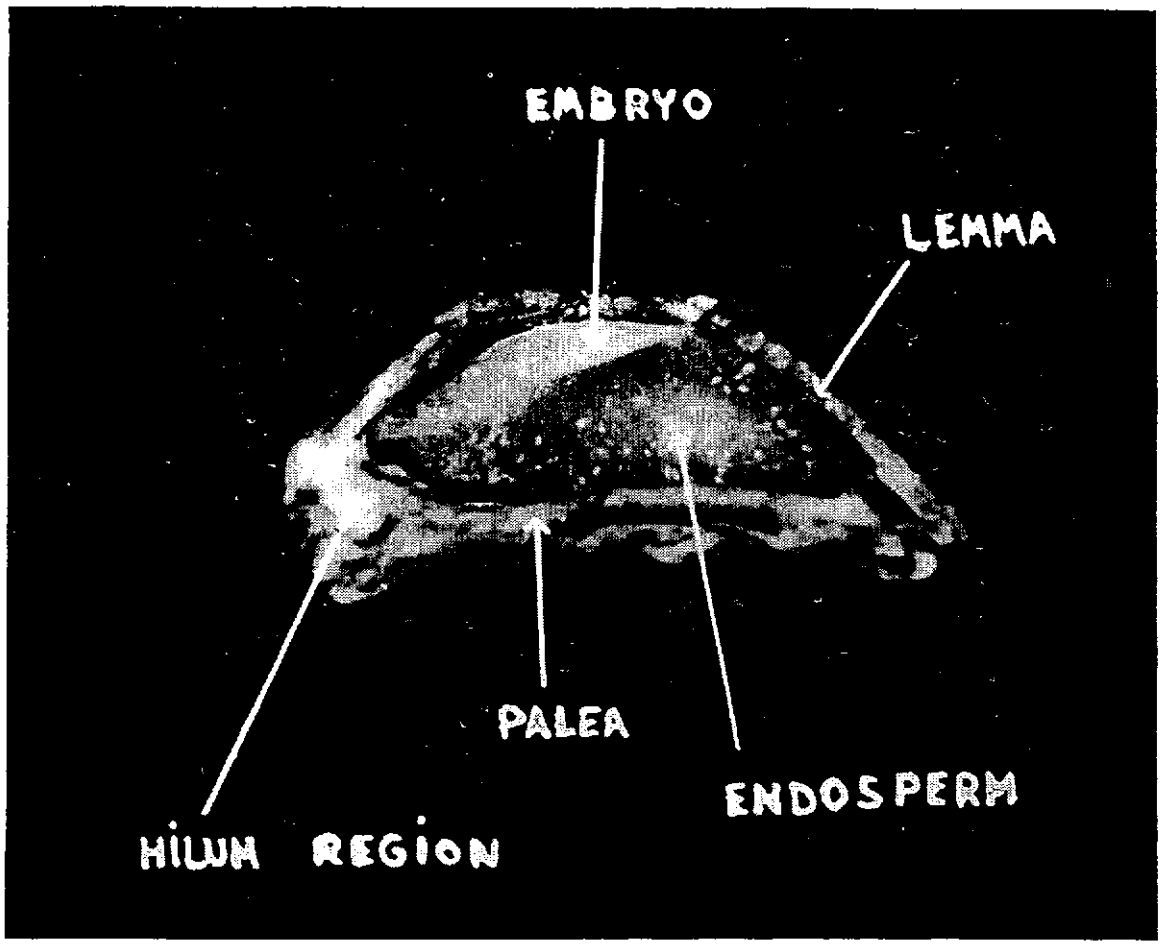


Figure 3 — Yellow foxtail seed with glumes partially removed exposing the caryopsis

increase in size or weight of the seed. This response was evidence that the seed coat was not permitting the absorption of water; in other words, the seed was "hard". To substantiate this observation, seed was scarified with sandpaper or by immersing in fuming H_2SO_4 followed by thoroughly rinsing with water. Both methods of opening up the seed coat resulted in a marked increase of germination. Most effective was the soaking in acid for 30 minutes.

The increased absorption of aqueous solutions into the caryopsis following scarification was demonstrated by soaking both scarified and non-scarified seed in Loefler's blue dye for 24 hours. Little or no dye could be detected in the caryopsis of non-scarified seed. The dye was quite evident, however in the scarified seeds. There was a close correlation between the percentage of seeds absorbing dye and the germination percentage of a particular seed lot. Thirty seeds of a lot of seed which had over-wintered in the soil absorbed dye while dormant seed stored dry had only 5% absorbing the dye. The increased germination following over-wintering of seed in the soil is probably associated with the scarifying effect of alternate thawing and freezing.

Germinable seed which had not been scarified showed dye entry first in the hilum area. This indicates that the hilum is the first portal of water entry during after-ripening in a dry environment.

In addition to the mechanical treatments previously described, several chemical treatments were evaluated.

Soaking seed in either NH_4NO_3 or KNO_3 solutions in the 1 to 2% range significantly increased the percent germination from an average of 15% to 50% or more. A doubling in germination percentage was obtained in seed previously scarified in acid. Magnesium nitrate had relatively little effect when compared to NH_4NO_3 or KNO_3.

Treatments with the following chemicals gave negative or adverse results: indolacetic acid, thiourea, methyl alcohol, hydrogen peroxide and EPTC.

The data given above on breaking dormancy of yellow foxtail point clearly to non-absorption by the seed coat as an important factor preventing germination of yellow foxtail once after-ripening has occurred. Any condition which weakens the seed coat such as decomposition or mechanical erosion from alternate thawing and freezing will permit germination of viable seeds.

The after-ripening period found necessary for germination of foxtail embryos was shortened by soaking seed in 25 ppm potassium gibberellate solution, if the seed coat was scarified enabling water absorption.

Giant Foxtail

The seed treatment which was most effective in inducing germination of giant foxtail was storage for two or more weeks at a temperature of 46°F. If storage was under both cold and moist conditions, germination was increased. Storage of seed collected in the fall of 1957 at 46°F on moist filter paper for 2 weeks gave a germination of over 90% in January 1958.

PROGRESSIVE DEVELOPMENT

Procedure

At both College Park and Storrs, previously collected seed was planted in wide-spaced nursery rows with the seedlings within the row thinned to stand 2 and 8 and 2 and 12 inches apart at the respective stations. At Storrs, a heavy volunteer infestation was studied with selected plants being separated 12 inches from adjacent plants by hand weeding. Data recorded periodically at both locations during the growing period included maximum extended height of plant, number of tillers, and stage of seed head development.

A greenhouse study at Storrs was carried out during early spring (February 20-May 2) during the short day photoperiod. A long day treatment was

obtained by continuous exposure during the hours of darkness to a 40 watt incandescent light. Measurements periodically recorded indicated maximum extended height, number of tillers, number of leaves and development of inflorescence.

The effect of shading on growth was determined at College Park in a greenhouse experiment. Controlled shading was obtained by using frames of parallel laths with different spacings between the laths. The light intensity of full sunlight in the greenhouse during this period as measured with a Weston illumination meter averaged 5300 fc. The light intensity under the laths was measured by the swing method using the photocell paddle of a Weston foot candle meter. Readings were made at random points and thus an average for both the shaded and unshaded areas was obtained.

The tendency of yellow foxtail to recover from mechanical control methods was investigated by determining the ability of several culms to re-establish by striking root. The ability of yellow foxtail to continue seed head formation following clipping was also determined.

To determine the occurrence of biotypes, seed was collected from individual plants at both locations with each station having one selection from the other state. Seeds from individual plants were planted the following year and periodic measurements were made of height, tiller number and seed head development. To determine variation in susceptibility to dalapon treatments, the selections were treated in the field with 2 pounds per acre of dalapon and in the greenhouse at the 2 leaf stage with 2 pounds acid equivalent of dalapon or at the 4 leaf stage with 4 pounds per acre.

At Storrs the influence of varying fertility levels on yellow foxtail yields was determined as well as the feed stuff analysis using standard methods.

Results and Discussion

Vegetative Development

Height increases in yellow foxtail followed a typical sigmoid growth pattern. Growth up to 2 to 3 inches was quite slow followed by rapid growth up to the time of heading. Germination both in the greenhouse and in the field occurred over a protracted time period. This prolonged germination period can be associated with the hard seed characteristics of this species as previously discussed.

The final height was determined to a large extent by the time of germination. Plants starting to grow in midsummer produced seed heads in a shorter period of time and consequently achieved less height. This was attributed to a photoperiodic response.

The influence of day length on jointing and subsequent heading was established in the greenhouse experiment (Table 1). Under continuous light conditions, no head formation had occurred even after 12 weeks of growth. Heading had started by the 7th week on plants subject to normal short daylight conditions of late winter.

Table 1. Yellow foxtail development under long and short day light conditions.

Photoperiod	Number of weeks after emergence				
	6	7	8	11	12
		Maximum height in inches			
Long day	8.0	10.6	14.1	17.0	18.4
Short day	9.7	11.5	13.6	21.0	22.0
		Primary tillers per plant			
Long day	0.7	1.0	2.2	2.9	2.6
Short day	1.0	2.5	4.0	3.3	3.3
		Leaves per plant			
Long day	5.2	6.3	9.5	14.9	18.0
Short Day	7.0	10.1	13.3	13.7	13.7
		Seed heads per plant			
Long day	None	None	None	None	None
Short day	None	1.0	4.0	7.0	7.0

The principal factor determining the weight of individual foxtail plants is the number of tillers. The first or primary tillers form from adventitious buds in the lower nodes of the initial culm. These tillers in turn may produce secondary tillers. Many tertiary tillers are produced as well.

Tiller numbers varied greatly from plant to plant with both spacing and day length being controlling factors. In an outdoor experiment the average for the Maryland plants was 75 tillers for plants spaced 8 inches apart but only 26 for plants spaced two inches apart. Plants in Connecticut averaged the same number of tillers at the two inch spacing but only 80% as many as in Maryland at the 12 inch spacing.

Further evidence of the effect of spacing is given in Table 2. In a natural infestation only two tillers formed per plant as compared to 56 tillers on plants spaced 12 inches from other plants.

The influence of day length on tiller information is also shown by the data in Table 2. Spaced plants which did not germinate until July were markedly restricted in total number of tillers formed. Since there is one seed head per tiller, the number of seed heads was also reduced on the late germinating plants.

In a Maryland experiment, the marked influence of shading upon development of yellow foxtail was established. The data are given in Table 3. Shading significantly decreased both plant height, number of tillers and dry

Table 2. Yellow foxtail development as influenced by density of stand[1]

Stand	Date of observation						
	July 20	27	Aug. 11	18	28	Sept. 11	19
	Maximum height in inches						
Spaced[2]	9.0	13.0	21.0	27.0	33.0	42.0	45.0
Non-spaced	—	12.0	21.0	25.0	29.0	37.0	41.0
Spaced-late[3]	2.0	4.5	10.0	15.0	17.0	26.0	30.0
	Tillers per plant						
Spaced[2]	2.3	9.0	25.0	36.0	43.0	55.0	56.0
Non-spaced	—	0.3	2.7	2.3	2.3	2.0	2.0
Spaced-late[3]	—	2.3	5.3	7.0	8.6	8.6	11.0
	Seed heads per plant						
Spaced[2]				3.3	16.7	40.0	47.0
Non-spaced				0.7	1.0	2.0	2.0
Spaced-late[3]				—	—	3.7	6.8

[1]Storrs, Connecticut—1958.
[2]Plants no closer than 12 inches to other plants.
[3]Late in emergence as compared with other plants.

Table 3. The effect of shading on the growth of yellow and giant foxtail.

% Shade	Plant Height (cm)	No of tillers	Av dry weight per plant (gm)
	Yellow foxtail		
0	23.8	6.1	0.92
60	19.8†	2.4‡	0.31‡
90	15.2†	2.7‡	0.09‡
	Giant foxtail		
0	28.8	4.0	1.07
60	20.2‡	2.9†	0.27‡
90	11.6‡	1.0‡	0.02‡

†Significant decrease at the 5% level.
‡Significant decrease at the 1% level.

weight per plant of both species. At 60 per cent shading the dry weight was decreased two-thirds while at 90 per cent the dry weight was negligible.

The degree of recovery of yellow foxtail after clipping to a two inch height on August 29 at Storrs, Connecticut was noted. This clipping did not prevent the formation of very short tillers, each producing a seed head.

Cultivation was shown to be an imperfect way of controlling yellow foxtail since culms placed in a moist rooting medium rooted readily. With both giant and yellow foxtail at least 75% of the primary stem and first tillers rooted as did at least 50% of the second and third tillers.

The seed producing potential of yellow foxtail was shown by a seed count of 7 individual seed heads. The average count was 180 seeds per head.

Yellow foxtail was responsive to increased fertility levels as shown by the data in Table 4. The greatest response was obtained from nitrogen. Eight hundred lb per acre of 5-10-5 resulted in over 1800 lb dry matter per acre while 800 lb of 10-10-5 gave 2500 lb dry matter.

Table 4. Response of yellow foxtail to varying fertility levels.

Fertilizer in lb/A		lb/A dry matter
400	5-10-5	1700
800	5-10-5	1840
800	10-10-5	2540

Yellow foxtail is a frequent component of forage cut during the year of seeding. A feed stuff analysis of plants cut in early bloom indicated a higher protein content than that found in timothy at the same stage, a somewhat greater fat content, and lower fiber content. The analysis indicated 10% protein, 3.7% fat, and 25.5% fiber.

BIOTYPES

In general, considerable variation in size of plant, habit of growth, and time of blooming was observed between seed lots. Variation among the 15 to 20 plants measured within a seed lot was relatively slight.

Results from a 1959 study of field grown foxtail plants in Maryland are given in Table 5. The rather wide range between selections is evident. The

Table 5. Variation in development between selections of yellow foxtail plants.

Origin of seed	Plant Height (cm)	Tiller No	Lodging	Heads per plant	Stage of Maturity
Maryland					
Picomico	35	20.4	Yes	18.9	Hard dough
Dorchester	43	21.8	No	17.2	Soft dough
Caroline A	42	26.9	Yes	26.1	Hard dough
Caroline B	40	15.3	Yes	12.3	Soft dough
Talbot	25	13.1	No	7.6	Soft dough
Queen Anne	32	14.8	No	8.0	Milk
Montgomery	53	20.1	No	19.7	Hard dough
Prince George	41	14.5	No	12.6	Hard dough
Connecticut	41	14.5	Yes	14.5	Hard dough

range in height from 25 to 43 cm was largely a reflection of the tendency of some selections to assume a more prostrate habit of growth. There was little correlation between height and degree of lodging.

Giant foxtail selections varied in height from 104 to 150 cm and in tiller number from 7.1 to 15.1. In general, the giant foxtail was taller, had fewer tillers, and was less variable than yellow foxtail.

Both foxtail species displayed considerable variability in response to dalapon treatments. Plants not sprayed until the 4 leaf stage were temporarily injured but later recovered when sprayed with 4 lb per A. When sprayed at the two leaf stage with 2 lb per A considerable variation between selections was observed. Some selections were killed while others were stunted but produced seed.

COMPETITION IN ASSOCIATED GROWTH

Procedure

Yellow foxtail and alfalfa were grown alone and in association in greenhouse experiments. Fifteen plants of each species, alone or in mixture, were grown in cans 6 inches in diameter of approximately one gallon size.

The fertility level was the variable employed. Soil moisture was maintained near field capacity. Light competition was not considered to be an important variable because of the relatively few plants per pot. When the alfalfa started to bloom the top and root tissue was removed for dry weight determinations and tissue analysis for P and K. Phosphorus was determined, after digestion, colorimetrically using the Vanado-molybdate method. Transmission was measured with an Evelyn photo-electric colorimeter with a 420 mm filter. Potassium was determined on an "Advanced Flame Photometer" using lithium as an internal standard.

Results and Discussion

The marked competitive effect of foxtail on the alfalfa seedlings was in-

Table 6. Effect of fertility levels on alfalfa and yellow foxtail alone and in association.

Fertility level lb/A N-P_2O_5-K_2O	Top growth Dry matter per pot (gm) Alfalfa		Foxtail	
	Alone	Association	Alone	Association
50-150-50	1.1	0.5	3.2	2.2
100-300-100	1.5	0.7	4.9	3.4
200-600-200	2.0	0.5	7.1	5.4
Average	1.5	0.6	5.1	3.8

dicated by a 60 percent decrease (1.5 to 0.6 gm) in alfalfa yield when foxtail was grown in association with alfalfa. The foxtail was decreased only 25 percent (5.1 to 3.8 gm) in association. Yields of both species were increased by each increment of fertilizer except for alfalfa when grown in association with foxtail.

It is evident that the increasing fertility level did not increase the competitive ability of alfalfa over foxtail. The foxtail response was greater, thus rendering this species even more competitive.

Tissue analyses for K and P in the top growth of each species was made to allow evaluation of nutrient absorption as a competitive factor. Table 7 shows that in alfalfa alone, the P and K percentage tended to increase as the fertility level increased. The increase in P and K in the alfalfa growing in association with yellow foxtail was much less. The P and K content of alfalfa growing in association was no greater at the highest fertility level than in alfalfa

Table 7. Effect of fertility levels on potassium and phosphorous content of yellow foxtail and alfalfa grown alone and in association.

Fertility[1] level	% K in top growth				%P in top growth			
	Alfalfa		Foxtail		Alfalfa		Foxtail	
	Alone	Association	Alone	Association	Alone	Association	Alone	Association
L_1[1]	1.6	1.1	2.2	2.4	0.20	0.15	0.14	0.15
L_2	1.9	1.2	2.0	2.1	0.18	0.17	0.14	0.16
L_3	2.3	1.5	2.1	2.1	0.25	0.19	0.15	0.16
Average	1.9	1.3	2.1	2.2	0.21	0.17	0.14	0.16

[1]See treatments in Table 6.

growing alone at the lowest fertility level. There was essentially no change in the foxtail, alone or in association, as the fertility increased.

These data indicate relatively greater absorption of P and K by foxtail than by alfalfa growing in association. This is in line with the work of Drake *et al* (6) on the relatively high uptake of K by plants having a low cation exchange capacity. Of 21 grasses studied, these workers found foxtail to have the lowest exchange capacity (11.4 me/100 gm). The capacity of alfalfa roots was found to be four times as great. When either P or K levels in the soil solution are lowered to a level which may be limiting, the greater absorptive ability of foxtail may become critical in the growth of alfalfa.

A Maryland experiment with alfalfa confirmed the failure of an increased fertility level to decrease foxtail competition with alfalfa. The results with soybeans differed. Under low fertility, giant foxtail caused a decrease in dry weight of soybeans while yellow foxtail did not cause a change. High fertility resulted in no change with giant foxtail and a marked increase in yield of soybeans growing with yellow foxtail.

PRODUCTION OF A GROWTH INHIBITOR

Procedure

The Connecticut experiments were made from extracts of yellow foxtail obtained as follows. The tissue was dried in a forced air drier at 60-65°C for 24 hours and ground to pass a 40 mesh sieve in a Wiley mill. Five grams of the ground material was added to 100 ml of distilled water. This mixture was autoclaved for 10 minutes at 15 pound pressure at 260°F and then filtered on a Buckner funnel. The filtrate was again autoclaved as above.

Details on the various procedures employed are given by Yokum, Jutras and Peters. (31)

Results and Discussion

Seeds of Ladino clover, sweet clover, birdsfoot trefoil and alfalfa all displayed reduction in germination when aqueous extracts of yellow foxtail plant tissue were used for wetting the filter paper employed as a germinating medium.

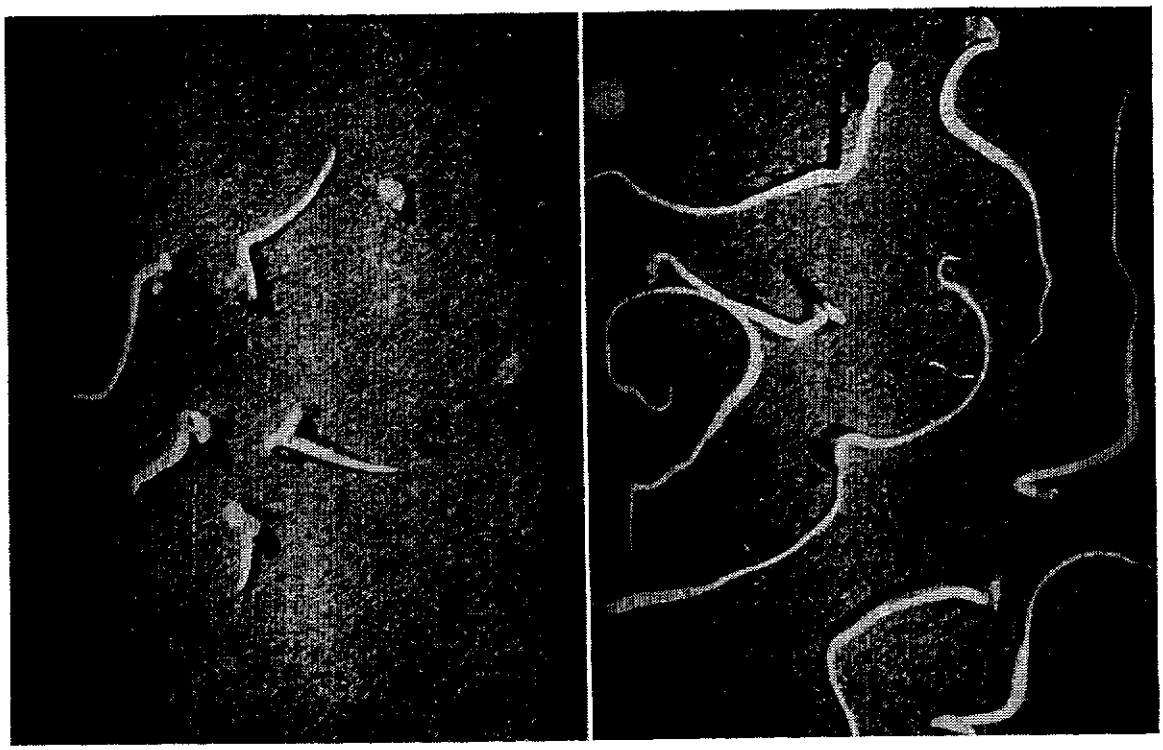


Figure 4 — Inhibition of alfalfa seedlings growing on foxtail tissue extract compared with normal growth

When germination did occur many of the radicles were abnormal, being thickened and reduced in length. Some inhibition, but distinctly less, occurred from giant foxtail extracts.

Since alfalfa consistently germinated less than 15% in the presence of the foxtail extract and germinated 100% with water only, this species was chosen as the bio-assay plant.

Using the bio-assay method of detecting the presence of the inhibitor, it was found that the inhibitor was present in either fresh or dried material. In the Connecticut work extracts from tops or roots were equally inhibitory. The Maryland work, however, indicated that the tops contained more of the inhibitor than the roots.

An attempt was made to characterize the inhibitor using a series of chemical procedures. It was found that the inhibitor was stable to autoclaving at 260°F. However, since it was destroyed by ashing, an organic substance was suggested.

Centrifuging and freezing had no effect on the inhibitor. Methanol extracted the inhibitor in a soxhlet extractor while ether, chloroform, benzene and acetone did not. Dialysis of the water extract removed the inhibitory fraction. No absorption occurred on AR-120 cationic ionic amberlite exchange resin in either Connecticut or Maryland tests. Results with the IRA-400

amberlite anionic exchange resins were inconclusive with no retention observed in Connecticut tests but with retention occurring in Maryland tests. When passed through both exchanges, no retention occurred.

Using descending chromatography and a 4-1-5 N-butyl alcohol, acetic acid, water solvent, it was found that strong absorption occurred in areas 2 and 7 with Rf values of 0.13 and 0.75. These sections of the chromatographs show a strong test for sugar. The exact sugar involved has not been determined.

SUMMARY

A cooperative study of yellow and giant foxtail was performed by the Storrs (Connecticut) and Maryland Agricultural Experiment Stations as part of the NE-42 Cooperative Regional Research Project. Yellow foxtail was found to have more morphological variability.

Dormancy of yellow foxtail seed was associated with impermeability of the seed coat to water. Weakening the seed coat permitted germination of viable seeds. The percent germination was increased by having 1 to 2% NH_4NO_3 or KNO_3 in the water.

Giant foxtail was successfully germinated when held in a moist condition at 46°F for 2 weeks.

Height increases in yellow foxtail followed a typical sigmoid growth pattern. Spacing influenced tiller number with uncrowded plants producing an average of 50 or more tillers per plant as compared with two tillers on crowded plants. Long day light conditions inhibited seed head formation but increased tiller formation.

Shading severely reduced the growth of both yellow and giant foxtail. Clipping yellow foxtail did not prevent seed head formation. Plants disturbed by cultivation rerooted.

Analysis showed that yellow foxtail cut as forage was more nutritious than timothy. It was highly responsive to nitrogen fertilizer. Yellow foxtail competed with alfalfa for phosphorous and potassium, decreasing the yield and mineral content of this legume. Under low fertility, giant foxtail caused a decrease in dry weight of soybeans. High fertility caused a marked increase in yields of soybeans growing with yellow foxtail but had little effect when this legume was associated with giant foxtail.

An autoclaved, distilled water extract of yellow foxtail inhibited the germination of alfalfa seed. The inhibitory material was a sugarlike substance.

LITERATURE CITED

1. Anon. 1962. The Manual for testing agriculture and vegetable seeds. U. S. D. A. Handbook 30. p. 128.
2. Allard, H. A. 1941. Some plants found in northern Virginia and West Virginia. Va. J. Sci. 2:116-119.
3. Bennett, E. L. and Bonner, J. 1953. Isolation of plant growth inhibitors from *Thamnosma montana.* Amer. J. Bot. 40:29-33.
4. Bonner, J. 1950. The role of toxic substances in the interactions of higher plants. Bot. Rev. 16:51-65.
5. Dawson, J. H. and Bruns, V. F. 1962. Emergence of barnyard grass, green foxtail, and yellow foxtail seedlings from various soil depths. Weeds 10:136-139.
6. Drake, M., Vengris, J. and Colby, W. Cation-exchange capacity of plant roots. Soil Sci. 72:139-147. 1951.
7. Evanari, M. 1949. Germination inhibitors. Bot. Rev. 15:153-194.
8. Evers, R. A. 1949. *Setaria faberii* in Illinois. Rhodora. 51:391-392.
9. Fernald, M. L. 1944. *Setaria faberii* in Eastern America. Rhodora 46:57-58.
10. ———. 1950 Gray's manual of Botany, 8th Ed. American Book Co., New York, 632 pages.
11. Gleason, H. A. 1952. The new Britton and Brown illustrated flora. The New York Botanical Garden, New York, 589 pages.
12. Hitchcock, E. E. 1951. Manual of the grasses of the United States, 2nd ed. U. S. Dept. Agri. Misc. Pub. 200.
13. Hubbard, F. T. 1915. A taxonomic study of *Setaria italica* and its immediate allies Am. J. Botany 2:169-198.
14. ———. 1916. Notes on Gramineae. Rhodora 18:187-196.
15. Peters, R. A. and Yokum, H. C. 1961. Progress report on a study of germination and growth of yellow foxtail (*Setaria glauca* (L.) Beauv.) Proc. NEWCC 15: 350-355.
16. Kephart, L. W. 1923. Quackgrass. U. S. Dept. Agri. Farmers Bull. 1307.
17. Koering, R. and Johnson, C. R. Colorimetric determination of phosphorus in biological materials. Ind. Eng. Chem. Anal. Ed. 14:155-156. 1942.
18. King, L. J. 1952. Germination and chemical control of the giant foxtail grass. Contrib. Boyce Thompson Inst. 16 (11):469-489.
19. Knake, E. L. and Slife, F. W. 1962. Competition of *Setaria faberii* with corn and soybeans. Weeds 10:26-29.
20. Kommendahl, T., Kotheimer, J. B., and Bernardini, J. V. 1959. The effects of quackgrass on germination and seedling development of certain crop plants. Weeds 7:1-12.
21. Le Tourneau, D., Failes, G. D., and Heggeness, H. C. 1956. The effect of aqueous extracts of plant tissues on germination of seeds and growth of seedlings. Weeds 4:363-368.
22. Le Tourneau, D., and Heggeness, H. C. 1957. Germination and growth inhibitors in leafy spurge foliage and quackgrass rhizomes. Weeds 5:12-17.
23. Nieto, J. H. and Staniforth, D. W. 1961. Corn-foxtail competition under various production conditions. Agron. J. 53:1-5.
24. Pohl, R. W. 1951. The genus *Setaria* in Iowa. Iowa State Col. J. of Sci. 501-508.
25. Santelmann, P. W. and Meade, J. A. 1961. Variation in morphological characteristics and dalapon susceptibility within the species *Setaria lutescens* and *S. faberii.* Weeds 9:406-410.
26. Staniforth, D. W. 1958. Soybean-foxtail competition under varying soil moisture conditions. Agron. J. 50:13-15.
27. Staniforth, D. W. 1961. Responses of corn hybrids to yellow foxtail competition. Weeds 9:132-136.
28. Staniforth, D. W. and Weber, C. R. 1956. Effects of annual weeds on the growth and yield of soybeans. Agron. J. 48:467-471.
29. Weber, C. R. and Staniforth, D. W. 1957. Competition relationships in variable weed and soybean stands. Agron. J. 49:440-444.
30. Wood, C. E., Jr. 1956. *Setaria faberii* in North Carolina. Rhodora 48:391-392.
31. Yokum, H. C., Jutras, M. W. and Peters, R. A. 1961. Preliminary investigations of a germination and growth inhibitor produced by yellow foxtail (*Setaria glauca* (L.) Beauv. Proceedings NEWCC 15:341-350.