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The effect of management variables on the establishment of some small-seeded legumes and grasses

Clyde D. Fisher

To the Graduate Council:

I am submitting herewith a thesis written by Clyde D. Fisher entitled "The effect of management variables on the establishment of some small-seeded legumes and grasses." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

Henry A. Fribourg, Major Professor

We have read this thesis and recommend its acceptance:

L. N. Skold, R. E. Shanks

Accepted for the Council:
Carolyn R. Hodges

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(Original signatures are on file with official student records.)

March 5, 1958

To the Graduate Council:

I am submitting herewith a thesis written by Clyde D. Fisher entitled "The Effect of Management Variables on the Establishment of Some Small-seeded Legumes and Grasses." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

Henry H. Fuberg
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We have read this thesis and recommend its acceptance:

Laurence V Skold

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Accepted for the Council:

Dale Hamblin
Dean of the Graduate School

THE EFFECT OF MANAGEMENT VARIABLES ON THE ESTABLISHMENT OF SOME SMALL-SEEDED LEGUMES AND GRASSES

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

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by

Clyde D. Fisher

March 1958

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TABLE OF CONTENTS

CHAPTER PAGE

CHAPTER PAGE

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

FIGURE PAGE

CHAPTER I

INTRODUCTION

Failures of both spring- and fall- sown stands of small-seeded grasses and legumes in Tennessee may be attributed in large part to the low fertility status of some soils and seedbeds and to the seeding of species not suitable for a particular soil condition. By adding the necessary mineral nutrients as indicated by soil tests and by seeding adapted species, these conditions may be almost completely surmounted. However, there often come into play some factors over which man has less control and which are not so easily overcome. For example, spring rains may result in later seeding dates than are generally recommended. As a result, after seedlings start growth, competition from weeds, drought or hot weather may cause failure of, or severe reduction in, the stand. Fall seeding failures also may be caused by drought or delayed seedings occasioned by abnormal rainfall. These conditions may result in poor seedling establishment and subsequent winter-killing due to heaving caused by alternate freezing and thawing of the soil. It is not easy to conceive of a way in which the hazards involved can be eliminated, but it may be possible to alleviate the severity of injury by making conditions favorable for rapid establishment and seedling growth of the species involved.

The conventional method of seeding pastures in Tennessee involves the broadcasting of both seed and fertilizer. Good stands may or may not be obtained in this manner, depending on conditions existing during the establishment period. Since several states and other countries have reported success with a method of forage establishment called "band seeding"

and since there is a lack of information concerning the applicability of this technique in Tennessee, it appeared that such a method might offer possibilities in overcoming some of the hazards involved in forage establishment. This method involves the placement of fertilizer in a way that a minimum of seedling injury occurs and maximum nitrogen, phosphorus and potassium are in proximity to the roots at the time they are needed by the plant. This is usually accomplished by sowing small-seeded grasses and legumes directly over a band of fertilizer with about one and one-half inches of soil separating the seed from the fertilizer.

The general objectives of this investigation were as follows:

1. To study the effects on stand establishment of different amounts of banded and broadcast fertilizer applied with various rates of banded and broadcast seed.

2. To study competition effects between grasses and legumes seeded alone and in combination at different rates when both seed and fertilizer are banded.

3. To determine the separate effects on establishment of the placement of bands of nitrogen and potassium fertilizer and phosphorus fertilizer in relation to the placement of seed.

4. To determine the effect on seedling establishment of the distance of the fertilizer band from seed at different fertilization rates.

CHAPTER II

REVIEW OF LITERATURE

Fertilizer Placement

The majority of early fertilizer placement studies were concerned primarily with the fertilization of row crops and small grains. Only recently has the accurate placement of forage crop seed relative to fertilizer position received due attention.

In 1925, Truog et al. (23) concluded from fertilizer experiments with corn and small grains that fertilizer in considerable concentration should never be allowed to come in direct contact with the seed, otherwise germination was greatly delayed or entirely prevented. Findings were essentially the same in fertilizer trials with corn conducted by Coe (5) in 1926, who pointed out that there were factors modifying the extent of injury, namely: rainfall, soil type, kind of seed and kind of fertilizer. Coe recommended, on the basis of his experiments, that those planters so designed as to place fertilizer in direct contact with the seed should be redesigned and a "sides method", or fertilizer placement to the side of the seed, should be used. To summarize the efforts of various workers for the period 1925-28, the National Joint Committee on Fertilizer Application published a report compiled by Truog and Jensen (24). The writers made the statement quoted below which is responsible, perhaps, for later developments: "A given amount of fertilizer applied in or near the row is more effective than the same amount applied broadcast". The report also pointed out that emphasis should be placed on studying the movement of mineral nutrients relative to the methods of

application, as it was generally thought that phosphorus had less tendency to move in the soil than nitrogen or potassium.

During the following ten years, information was published concerning the availability of phosphorus in different phosphatic compounds. Midgley (17) in 1931, and Brown and Munsell (3) in 1936, reported that the downward movement of phosphorus from superphosphate was very slow. Midgley's work in Wisconsin is of interest because of the attention given to sub-surface band placement of phosphates in permanent pastures. On field plots of Kentucky bluegrass, Poa pratensis L. and white clover, Trifolium repens L., washing superphosphate into knife grooves, six inches deep and four inches apart, increased the yield of grass fifty-seven percent more than surface application of the same amount of superphosphate. Pierre (18) in 1938 indicated that a practical means to increase the availability and efficiency of phosphorus would be to make the application in the form of bands, thus reducing the fixation that occurs when the fertilizer is placed in direct contact with the soil mass. Band placement reduced the fixation of both phosphorus and potassium in work reported by Salter (19) and increased efficiency of both nutrients, especially on fine-textured soils high in colloidal material.

In bean experiments carried out at Cornell in 1935 by Sayre and Clark (20), the soluble nitrogen and potassium salts proved to be the chief cause of damage to germinating seeds injured by improperly placed fertilizers. Salter (19) stated that the most important cause of fertilizer injury was the excessive salt concentration in the soil solution coming into direct contact with the seed or young plant. Phosphorus fertilizers, then, may be applied more closely to germinating seeds or seedlings than either nitrogen or potassium.

Fertilizer Movement

A perception of the movement of fertilizer materials after application to the soil is necessary for understanding the relationships of fertilizer placement.

Salter (19) and Sayre and Clark(20) have shown that fertilizer movement is vertical, following soil moisture fluctuation, with only slight diffusion of ions laterally. Nitrates were found to move most freely, ammonium and potassium salts somewhat less and phosphate very little. A report by Hill (15) pointed out the slight movement and distribution of phosphorus from superphosphate band applications.

Seeding Methods

The customary way of sowing small-seeded legumes and grasses for forage has been by broadcast methods. Drilling with an ordinary grain drill is sometimes used but shallow enough coverage of the seed is often difficult to obtain. Coverage can usually be accomplished by the use of a cultipacker, but often some seeds are covered too deeply and others too shallowly. In Tennessee, it has been a common practice to broadcast forage species such as red clover, Trifolium pratense L. and Ladino clover, Trifolium repens L., on the frozen soil surface in late February or early March in established fall-sown small grains or established grass stands. No coverage effort is necessary as movement of the soil from alternate freezing and thawing causes seed coverage. When temperatures permit, germination and establishment take place. A hazard of this method is that heaving, cold injury and other effects of inclement weather may occur

after emergence of the seedlings with resultant loss of the stand.

Development of Band Seeding

Thatcher et al. (22) observed in Ohio the strikingly better growth of alfalfa, Medicago sativa L., over a drilled band of phosphate than between the drill rows. Blaser and McAuliffe (2) obtained more forage at the first harvest from Ladino clover grown over a phosphate band than when an equal amount of phosphate was broadcast. Further, a larger percentage of the phosphorus from the fertilizer was absorbed by the Ladino clover from the drilled than from the broadcast applications. Experimental work was carried out in England by Cooke (6) in 1950-51 comparing broadcast dressings of phosphorus and potassium fertilizers with the same quantities of fertilizer placed in a band two inches to the side of the seed and three inches below the soil surface. The broadcast applications proved to be as effective as the "side method" in obtaining early growth and similar yields resulted in both years.

Haynes and Thatcher (12) in 1950 were the first workers in the United States to describe a new method of seeding that they called "band seeding". The method consisted of sowing small-seeded grasses or legumes directly over a band of fertilizer with about one to one and one-half inches of soil separating the seed from the fertilizer. The planting and fertilization operations were carried out with an ordinary grain drill modified by extending the tubes from the grass seed box. Special grassland drills now sold commercially have follower or press wheels to roll the seeds, thus eliminating the cultipacking operation deemed desirable when the modified grain drill is used. The above-cited authors declared

that legumes in the seedling stage obtain mineral nutrients slowly, maintaining that even when grown on fertile soil, alfalfa is four or five weeks old before it is capable of obtaining sufficient amounts of soil nutrients for significant growth.

In 1951 Haynes and Thatcher (13) obtained yields from the seedings of the previous years at Wooster. The band seedings of alfalfa with 500 pounds per acre of 0-20-20 yielded approximately one and one-half times as much hay as obtained with equal amounts of broadcast seed and fertilizer. The yield differential was attributed largely to greater winter survival of the banded treatments, a factor of extreme importance following summer seedings.

Since good results were procured in Ohio by this combined method of seeding and fertilizer application, tests soon were conducted in other states. In Michigan, Tesar et al. (21) obtained, in alfalfa and birdsfoot trefoil Lotus corniculatus L.,tests, twenty-two percent more seedlings when seed was banded on top of the soil directly over fertilizer drilled in seven-inch rows, one and one-half inches deep, than when seed was broadcast on soils similarly fertilized. Band seeding also resulted in taller, more vigorous plants.

Due to the high establishment costs of permanent pastures, Hulburt et al. (16) of the United States Department of Agriculture, Beltsville, Maryland, initiated studies to determine the effectiveness of various methods of fertilization and the possibilities of reducing the amount of seed required for seedings. In a comparison involving twenty-four treatments, banding seed and fertilizer was superior to broadcasting seed or fertilizer or both with respect to reduced weed infestation, increased seedling numbers and higher initial forage yield.

Field and greenhouse experiments were conducted by Forbes (9) to study the effects of fertilizer placement on seedling establishment and early growth of forage crops. In the field studies, various fertilizer and seed treatments were used at different dates of seeding on soils of both high and low initial fertility. Alfalfa was the main species studied but limited seedings of birdsfoot trefoil-timothy, Phleum pratense L., and Ladino clover-orchardgrass, Dactylis glomerata L., mixtures, were made. No difference in the original stands was obtained from fertilizer treatments. Winter survival of fall-sown alfalfa was improved by phosphate fertilization only on the low fertility soil. Alfalfa produced larger initial yields from the banded than from the broadcast treatments but the advantage tended to diminish as the season progressed. Ladino clover and birdsfoot trefoil yields were slightly increased from phosphate fertilization but no difference occurred between methods of application. Greater survival differences resulted from different dates of fall seeding at the low fertility site than from different fertilizer rates or placement treatments.

Haynes and Thatcher (14) and others (1, 11) have summarized the advantages of band seeding as follows:

a) Better germination and emergence is obtained by controlled soil coverage.

b) Fertilizer is used more efficiently by seedlings.

c) Individual plants grow more vigorously from the start and can survive less favorable conditions.

d) Weeds usually cause less trouble because the nutrients from the fertilizer are less accessible between the rows.

e) Forage seed and fertilizer can be applied in a single operation.

f) Only two-thirds as much legume seed and one-half as much grass seed are required for band seeding as for broadcast seeding.

CHAPTER III

METHODS AND MATERIALS

Location and Field Plot Design

The results reported herein are based primarily on experiments conducted at the University of Tennessee Experiment Station, Blount County, in the spring and fall of 1957. Similar experiments were planted in the fall of the same year at the Middle Tennessee Experiment Station, Maury County, and at the Highland Rim Experiment Station, Robertson County. Preliminary findings for the fall-seeded experiments will be discussed in lesser detail.

A spring seeding of four experiments and a fall seeding of two of these four were established at the Blount County site on Alcoa silt loam soil. Two slightly different experiments were seeded in the fall on Maury silt loam in Maury County and two others on Dickson silt loam in Robertson County.

Soil samples were taken prior to seeding and the fertility level determined by laboratory analysis. The pH was obtained with a glass-electrode Beckman pH meter and the phosphorus and potassium determined by the ammonium sulfate extraction method. Average determinations were as follows:

1. Alcoa silt loam: pH 6.4, low available phosphorus, high available potassium;

2. Maury silt loam: pH 6.3, medium to high available phosphorus and potassium;

3. Dickson silt loam: pH 5.8, low available phosphorus and medium

to high available potassium.

The experimental plots in all tests were 5.33 feet wide and twenty feet long with .66 feet left between plots for tractor wheel tracks. The treatments were arranged in a randomized complete block design and replicated four times, except at the Middle Tennessee Experiment Station, where three replications were used.

For all experiments, a good seed-bed was prepared by turning the soil, discing several times and section-harrowing. Only at the Highland Rim Experiment Station was the soil rolled, as a moisture retentive measure, before seeding.

Seeding Method

Test plots at all locations were seeded with a special experimental drill (Figure 1) developed by the United States Department of Agriculture, Agricultural Research Service, Agricultural Engineering Research Division, and operated by Mr. C. W. Gantt, Jr., of the U. S. D. A., A. R. S. This drill permits the precision placement of both seed and fertilizer in either broadcast or drilled patterns (25) (Figures 2 and 3). Since grass seed, legume seed and fertilizer are of a different size and weight, separate boxes with appropriate flow mechanisms for accurate calibrations were used. This permitted the seed and fertilizer to be applied in very small, known amounts, as desired.

Prior to seeding, the drill was calibrated for the application of different rates of each seed and fertilizer rates. The legumes were inoculated with the appropriate strains of Rhizobia immediately prior to seeding.

Figure 1. Special experimental drill developed by the United States Department of Agriculture, Agriculture Research Service, Agricultural Engineering Research Division and used for seeding and fertilizing experimental plots.

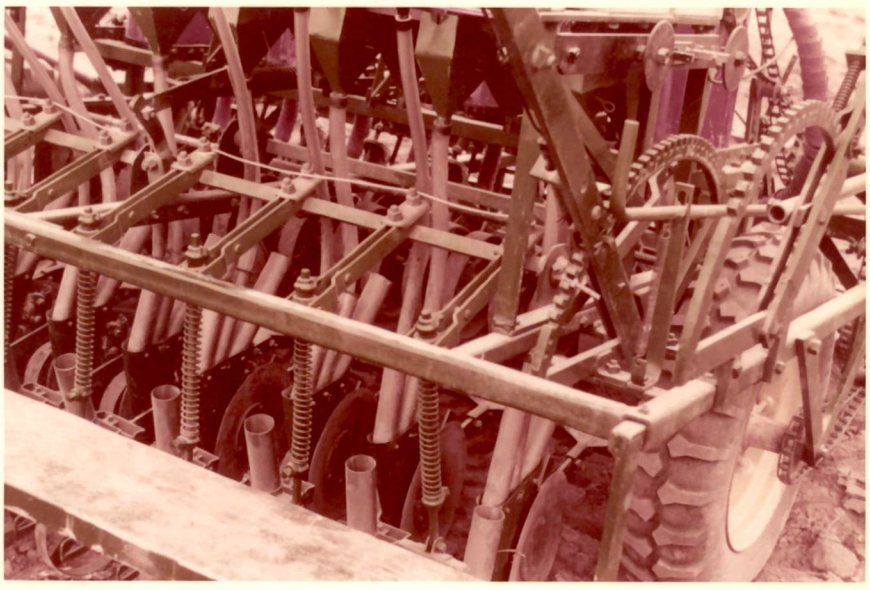

Figure 2. Close-up view of drill showing hoses from seed boxes which make possible either banding or broadcasting of seed by moving connecting delivery plastic hoses to different spouts.

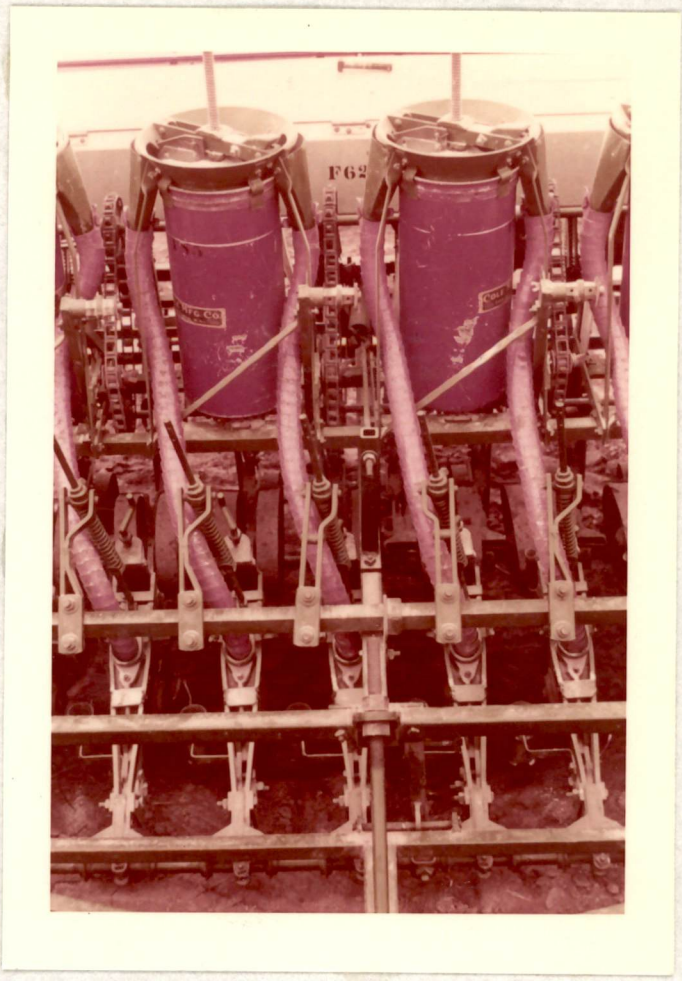

Figure 3. Close-up view of drill showing positive-delivery fertilizer boxes which permit either banding or broadcasting of fertilizer by moving the connecting steel ribbon tubes to different spouts.

When the seed treatments were banded, i.e., sown in eight, eight-inch rows, the soil surface was firmed directly over the row with a small press wheel, one inch wide, which is attached to the seed furrow opener of the drill. Where seed alone or both seed and fertilizer were broadcast, the plots were rolled with a "Brillion" double-corrugated roller (Figure 4). It may be noted that this extra operation is conventionally involved in the broadcast method of seeding.

The broadcast fertilizer treatments, however, differ somewhat from those commonly used by farmers. Only a small amount of the broadcast fertilizer was incorporated in the soil by the double discs that were used for the banding method, with the rest remaining on the soil surface. Conventionally the fertilizer is disced into the upper five or six inches of soil.

Seed and Fertilizer Treatments

Due to the number and complexity of treatments, a legend of abbreviations and symbols used in designating treatments is given in Table I. Tables II through IX list the various treatments by experiment. The varieties and species of forage crops used in tests were Buffalo alfalfa, Ladino clover, Kenland red clover, alsike clover, Trifolium hybribum L., Kentucky 31 fescue and common orchardgrass.

Experiment 1 was established for the purpose of testing two seeding rates of alfalfa plus orchardgrass at low and high fertility levels with all combinations of banded and broadcast seed and fertilizer.

In experiment 2, alfalfa, Ladino clover, orchardgrass and fescue were seeded alone and in combination at various rates to study competition

Figure 4. View of "Brillion" double-corrugated roller used in firming plots where seed alone, or both seed and fertilizer were broadcast.

TABLE I

LEGEND OF ABBREVIATIONS AND SYMBOLS
USED IN DESIGNATING TREATMENTS

Abbreviation or Symbol	Description
Alf.	Alfalfa
Fesc.	Tall Fescue
Lad.	Ladino clover
Orch.	Orchardgrass
B	Seed banded or placed in rows 0.5 inches below soil surface. Fertilizer placed in rows 1.5 inches below soil surface.
BC	Seed or fertilizer broadcast on soil surface. Only a small amount of the broadcast fertilizer was incorporated in the soils by the double discs that were used for the banding method. Conventionally the fertilizer is disced into the upper five or six inches of soil.
Fert.	Fertilizer
Lo	Fifteen pounds N, 60 lbs. P_2O_5 and 60 lbs. K_2O per acre, applied as 33.5 percent ammonium nitrate, 48.0 percent superphosphate and 60 percent muriate of potash, in all experiments except experiment 3. In the latter, "Lo, N, K" refers to 15-0-60 and "Lo P" refers to 0-60-0.
Hi	Fifteen pounds N, 120 lbs. P_2O_5 and 120 lbs. K_2O per acre, applied as 33.5 percent ammonium nitrate, 48.0 percent superphosphate and 60 percent muriate of potash, in all experiments except experiment 3. In the latter, "Hi N,K" refers to 15-0-120 and "Hi P" refers to 0-120-0.
1"b	Fertilizer placed 1.0 inch below seed.
1.5"b	Fertilizer placed 1.5 inches below seed.
2"b	Fertilizer placed 2.0 inches below seed.
2.5"b	Fertilizer placed 2.5 inches below seed.
1"b,1"s	Fertilizer placed 1.0 inch below and 1.0 inch to side of seed.
1"b,2"s	Fertilizer placed 1.0 inch below and 2.0 inches to side of seed.
Pos.	Position or placement of seed or fertilizer.

TABLE II

EXPERIMENT 1. TREATMENTS ESTABLISHED TO EVALUATE THE INTERACTION BETWEEN SEED RATES, PLACEMENT AND RATES OF FERTILIZER, BLOUNT COUNTY, APRIL 15, AND SEPTEMBER 27, 1957

Pounds Seed per Acre		Placement		Fert.
Alf.	Orch.	Seed	Fert.	Rate
10	5	BC	BC	Lo
10	5	BC	BC	Hi
10	5	BC	B	Lo
10	5	BC	B	Hi
10	5	B	BC	Lo
10	5	B	BC	Hi
10	5	B	B	Lo
10	5	B	B	Hi
20	10	BC	BC	Lo
20	10	BC	BC	Hi
20	10	BC	B	Lo
20	10	BC	B	Hi
20	10	B	BC	Lo
20	10	B	BC	Hi
20	10	B	B	Lo
20	10	B	B	Hi

TABLE III

EXPERIMENT 2. TREATMENTS ESTABLISHED TO EVALUATE THE EFFECT OF SEEDING RATE ON STAND ESTABLISHMENT WITH SEED BANDED AND FERTILIZER BANDED AT HIGH RATE, BLOUNT COUNTY, APRIL 13, AND SEPTEMBER 27, 1957

Pounds Seed per Acre			
Alfalfa	Ladino	Orchardgrass	Fescue
20			
	2		
		14	
			14
10		5	
10		10	
20		5	
20		10	
	1		7
	1		14
	2		7
	2		14
	1	7	
	1	14	
	2	7	
	2	14	

TABLE IV

EXPERIMENT 3. TREATMENTS ESTABLISHED TO EVALUATE THE EFFECT OF VARYING RATES AND POSITIONS OF NITROGEN, POTASSIUM AND PHOSPHORUS FERTILIZERS WITH BANDED SEED ON STAND ESTABLISHMENT, BLOUNT COUNTY, APRIL 13, 1957

Pounds Seed per Acre				Fertilizer Rate and Position			
				P_2O_5		N plus K_2O	N plus K_2O
Alf.	Lad.	Orch.	Fesc.	Rate	Pos.	Rate	Pos.
20		10		0	--	0	--
20		10		Lo	BC	Lo	BC
20		10		Hi	BC	Hi	BC
20		10		Lo	B	Lo	BC
20		10		Hi	B	Hi	BC
20		10		Lo	B	Hi	BC
20		10		Hi	B	Lo	BC
20		10		Lo	B	Lo	B
20		10		Hi	B	Hi	B
	2	14		0	--	0	--
	2	14		Lo	BC	Lo	BC
	2	14		Hi	BC	Hi	BC
	2	14		Lo	B	Lo	BC
	2	14		Hi	B	Hi	BC
	2	14		Lo	B	Hi	BC
	2	14		Hi	B	Lo	BC
	2	14		Lo	B	Lo	B
	2	14		Hi	B	Hi	B
	2		14	0	--	0	--
	2		14	Lo	BC	Lo	BC
	2		14	Hi	BC	Hi	BC
	2		14	Lo	B	Lo	BC
	2		14	Hi	B	Hi	BC
	2		14	Lo	B	Hi	BC
	2		14	Hi	B	Lo	BC
	2		14	Lo	B	Lo	B
	2		14	Hi	B	Hi	B

TABLE V

EXPERIMENT 4. TREATMENTS ESTABLISHED TO EVALUATE THE EFFECT OF VARIOUS DISTANCES BETWEEN SEED AND FERTILIZER WITH TWO FERTILIZATION RATES ANDTWO SEED MIXTURES ON STAND ESTABLISHMENT, BLOUNT COUNTY, APRIL 16, 1957

Pounds seed per Acre			Placement		Fert.
Alf.	Lad.	Orch.	Seed	Fertilizer	Rate
20		10	B	1.5"b	Lo
20		10	B	1.5"b	Hi
20		10	BC	BC	Lo
20		10	BC	BC	Hi
20		10	B	2.5"b	Lo
20		10	B	2.5"b	Hi
20		10	B	1"b,1"s	Lo
20		10	B	1"b,1"s	Hi
20		10	B	1"b,2"s	Lo
20		10	B	1"b,2"s	Hi
	2	14	B	1.5"b	Lo
	2	14	B	1.5"b	Hi
	2	14	BC	BC	Lo
	2	14	BC	BC	Hi
	2	14	B	2.5"b	Lo
	2	14	B	2.5"b	Hi
	2	14	B	1"b,1"s	Lo
	2	14	B	1"b,1"s	Hi
	2	14	B	1"b,2"s	Lo
	2	14	B	1"b,2"s	Hi

TABLE VI

EXPERIMENT 5. TREATMENTS ESTABLISHED TO EVALUATE INTERACTION BETWEEN SEED RATE, PLACEMENT AND RATES OF FERTILIZER, MAURY COUNTY, AUGUST 21, 1957

Pounds Seed per Acre		Placement		Pounds Fert. per Acre		
Alf.	Orch.	Seed	Fert.	N	P_2O_5	K_2O
10	5	B	BC	30	0	120
10	5	B	1"b,2"s	15	0	60
10	5	B	1"b,2"s	15	0	120
20	10	B	1"b,2"s	30	0	120
20	10	B	2"b	30	0	120
20	10	B	1"b,2"s	30	0	120
20	10	B	BC	30	0	120
20	10	BC	BC	30	0	120
20	10	B	BC	15	0	120
20	10	B	1"b,2"s	15	0	120
20	10	B	1"b,1"s	15	0	120
20	10	B	2"b	15	0	120
20	10	BC	BC	15	0	120
20	10	B	BC	15	60	60
20	10	B	1"b,2"s	15	60	60
20	10	B	1"b,1"s	15	0	60
20	10	B	2"b	15	0	60
20	10	B	1"b,2"s	15	0	60
20	10	B	1"b	15	0	60

TABLE VII

EXPERIMENT 6. TREATMENTS ESTABLISHED TO EVALUATE INTERACTION BETWEEN SEED RATE, PLACEMENT AND RATES OF FERTILIZER, MAURY COUNTY, AUGUST 21, 1957

Pounds Seed per Acre		Placement		Pounds Fert. per Acre		
Lad.	Orch.	Seed	Fert.	N	P_2O_5	K_2O
1	7	B	BC	15	0	60
1	7	B	1"b,2"s	15	0	60
1	7	B	1"b,2"s	15	0	120
2	14	B	1"b,1"s	15	0	60
2	14	B	2"b	15	0	60
2	14	B	1"b,2"s	15	0	60
2	14	B	BC	15	0	60
2	14	BC	BC	15	0	60
2	14	B	BC	15	0	120
2	14	B	1"b,2"s	15	0	120
2	14	B	1"b,1"s	15	0	120
2	14	B	2"b	15	0	120
2	14	BC	BC	15	0	120
2	14	B	BC	15	60	60
2	14	B	1"b,2"s	15	60	60

TABLE VIII

EXPERIMENT 7. TREATMENTS ESTABLISHED TO EVALUATE INTERACTION BETWEEN SEED PLACEMENT AND RATES AND PLACEMENT OF FERTILIZER, ROBERTSON COUNTY, AUGUST 22, 1957

Pounds Seed per Acre		Placement		
Lad.	Fesc.	Seed	Fert.	Fertilizer Rate
2	14	B	1"b,1"s	Lo
2	14	B	2"b	Lo
2	14	B	BC	Hi
2	14	B	1"b,1"s	Hi
2	14	B	2"b	Hi
2	14	BC	BC	Hi

TABLE IX

EXPERIMENT 8. TREATMENTS ESTABLISHED TO EVALUATE INTERACTION BETWEEN SEED PLACEMENT AND RATES AND PLACEMENT OF FERTILIZER, ROBERTSON COUNTY, AUGUST 22, 1957

Pounds Seed per Acre			Placement		Fert.
Alsike	Red clover	Fesc.	Seed	Fert.	Rate
4	6	7	B	1"b,1"s	Lo
4	6	7	B	2"b	Lo
4	6	7	B	BC	Hi
4	6	7	B	1"b,1"s	Hi
4	6	7	B	2"b	Hi
4	6	7	BC	BC	Hi

effects between grasses and legumes. Both seed and fertilizer were banded.

Different combinations of rates and placement of N and K fertilizers and of P fertilizer were used with three seed mixtures in experiment 3. This experiment was performed to study the effects on seed germination and growth of possible differences in the rate of movement of N, K and P in the soil.

In experiment 4, comparisons of "below, side-band" placement methods with ordinary band and broadcast methods at low and high fertilizer rates were made. Two seed mixtures were used with four of the twenty seed treatments broadcast and the others banded.

Experiments 5 and 6 were established at the Maury County site to compare seeding rates and placements of two seeding mixtures with various fertilizer rates and placements. Phosphorus was included in only four of the thirty-four treatments, to determine if it might be a limiting factor in obtaining forage stands on soils naturally high in phosphorus.

Robertson County experiments 7 and 8 included two seed mixtures which have been found to perform reasonably well on an imperfectly drained soil such as Dickson silt loam. Different rates and positions of fertilizer with different seed placements were used in this evaluation.

The eight experiments thus encompass a total of 156 treatments, of which 122 of these are replicated four times, and the other thirty-four are replicated three times, resulting in a total of 590 plots.

Stand Count Method

Stand counts were taken in May 1957 on experiments 1, 2, 3 and 4

approximately one month after seeding and again in June and October. An extra count was taken on experiment 4 in July, making a total of four counting dates for this particular test. Stand counts of fall-seeded crops were made on experiments 1, 2, 5, 6, 7, and 8 in September or October and another count was made on experiment 1 in February.

A systematic sampling procedure was employed in taking eight six-inch by eighteen-inch quadrats per plot from which the numbers of all living crop and weed plants were recorded. A bamboo pole, marked at one-foot intervals, was placed lengthwise in the center of the plot. As each band-seeded plot contained eight rows, there were four rows on either side of the pole. Only the two inside rows on each side of the pole were sampled while the two outside rows on each side of the plot were considered as border rows. The quadrat nearest to one end of the plot was placed so that it covered an area which was between two and two and one-half feet distant from the plot end. Each quadrat covered six-inch sections of two rows that were eight inches apart (as sown by the special drill used). Three more such quadrats were then placed at four-foot intervals, thus leaving four feet between the outside edge of the last quadrat and the further end of the plot. On the other side of the pole, four feet were left before counts were started, thus leaving two feet at the terminal point for a particular plot. By placing the quadrats in this fashion, and in the same way in all plots, they were staggered on either side of the pole, rather than opposite each other. The broadcast plots were counted in like manner, except that there were no rows to serve as a guide for quadrat placement.

General Agronomic Information

After the second stand counts were made on spring seedings at Blount County, Sclerotium rolfsii Sacc., a soil-borne fungus, was present on plots containing alfalfa. As the alfalfa was approaching full bloom, all plots were mowed to a height of about four inches and raked off. Forty pounds per acre of twenty percent "Terrachlor" (pentachloronitrobenzene) dust was then applied with a Hudson hand duster. Apparently the dusting, together with the clipping and raking, was beneficial, for little or no loss of alfalfa was observed subsequently.

Toward the latter part of July, insects were particularly prevalent on the alfalfa plots. These areas were clipped again, raked and dusted with twenty-five pounds per acre of twenty percent Toxaphene. Another application was made about a week later, due to rain wash-off following the initial dusting. The Hudson hand duster was again used in the operations.

Analysis and Presentation of Data

Since stands were poor on most treatments of the spring seedings and many quadrats had readings of zero, resulting in non-normal distribution of data, square root transformations were made as described by Freeman and Tukey (10) and Federer (8). To each quadrat count for each species, the factor 0.5 was added and the square root of the sum was obtained. Analyses of variance were then carried out in the usual manner. Counts from the fall seedings were much higher than those of the spring seedings and contained very few zero readings; hence, the analysis was

performed on the original data.

The counts are presented as plants per square foot, computed from the total number of plants counted in thirty-two, 108 square inch quadrats, where tests had four replications, and twenty-four, 108 square inch quadrats where there were three replications per test. Duncan's multiple range test (7) was used to determine the significance of differences at the five percent level of probability between stands obtained with the different treatments.

Statistical significance in the analysis of variance tables is indicated by the conventional use of asterisks as follows: significance at the five percent level of probability is denoted by * and at the one percent level of probability by **.

CHAPTER IV

RESULTS AND DISCUSSION

The experimental results presented in this thesis are based on the stand counts which show what methods and treatments are most likely to give satisfactory stands. The use of stand counts has the practical advantage that information of value is obtained without carrying the experiment through to later stages of plant development.

Spring Seedings at the Blount County Site

Weather conditions (Appendix A) greatly affected the results of spring seedings at the Blount County site. Adequate soil moisture was present at time of seeding but practically no rain fell the ensuing month.

Experiment 1. The effects of low and high fertilizer rates and positions and rates and placements of alfalfa-orchardgrass mixtures are presented in Figure 5 and Appendix B. Twenty pounds of alfalfa per acre resulted in better stands than ten pounds per acre, when comparing identical seed placements and fertilizer positions. Orchardgrass was practically absent in all broadcast-seeded plots regardless of the manner in which the fertilizer was applied. This result undoubtedly was due to the influence of the drought that followed seeding, as well as to inadequate seed coverage.

The better initial stands of the band-seeded alfalfa-orchardgrass plots were obtained when the fertilizer was broadcast or was banded at the low rate. An apparent reduction in stand when the fertilizer was banded

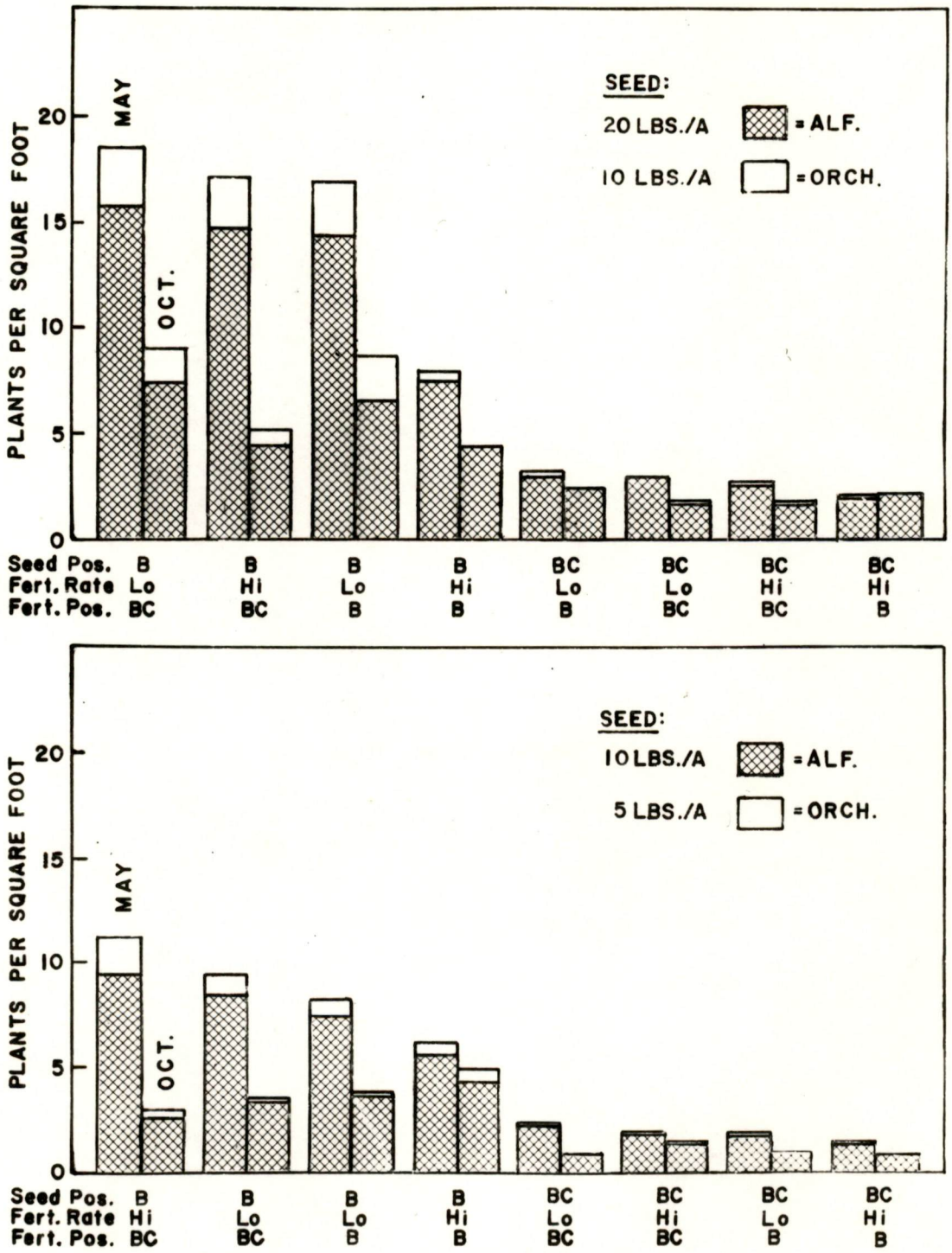

FIGURE 5. EXPERIMENT I. MAY AND OCTOBER 1957 STAND COUNTS OF ALFALFA AND ORCHARDGRASS FOLLOWING SEEDING ON APRIL 15, 1957 WITH VARYING FERTILIZER AND SEED RATES AND POSITIONS

at the high rate is probably a reflection of the effect of a high concentration of fertilizer inhibiting germination of the seed or causing seedling mortality after germination. When final 1957 counts were taken in October, the multiple range tests (Appendix B) indicated that the best treatment at the .05 level of probability was, for alfalfa, that where the seed was banded and the fertilizer broadcast at the low fertilization level and, for orchardgrass, that treatment where the seed was banded and the fertilizer was either broadcast or banded at the low level. Seed placement appeared to be of more importance than fertilizer position in this experiment.

Experiment 2. Counts which are presented in Appendix C were taken to determine competition effects between different rates of seeding of mixtures containing alfalfa-orchardgrass, Ladino-orchardgrass and Ladino-fescue as compared with pure seedings of the same species when seed was banded and fertilizer banded at the high rate.

At the time of seeding, the soil contained a more than adequate supply of moisture, resulting in the clogging of the packer wheels and improper coverage of the seed which was reflected in the poor and uneven stands obtained. Poor stands can be attributed also to the formation of a soil crust after seeding, as shown by Carnes (4), resulting in the seedlings being unable to break through the crust, and possibly to the high rate of fertilization used.

In the plots containing alfalfa alone and alfalfa-orchardgrass mixtures, the better initial stands of alfalfa were obtained from the high seeding rate of alfalfa alone or in combination with either high or low rates of orchardgrass. Orchardgrass stands in alfalfa were better

when orchardgrass was seeded at the high rate and alfalfa at the low rate.

Ladino clover stands, though very poor, were somewhat better when seeded alone at the high rate or at the high rate in combination with the low rate of fescue. The better fescue stands were obtained when fescue was planted at the high rate, either alone or in combination with low and high rates of Ladino.

In a comparison of orchardgrass when seeded alone and in combination with Ladino clover, better stand counts were obtained from the high orchardgrass seeding with no apparent influence from the Ladino at either high or low rate. The Ladino seeded alone gave a little better stand than when it was seeded in combination with orchardgrass at either high or low rate.

Generally, initial stands in this experiment were proportional to the seeding rate. Final 1957 stand counts indicated less differences in stand due to different rates of seeding.

Experiment 3. The effects of rates and positions of phosphorus and nitrogen-potassium fertilizer on forage species establishment with banded seed are presented in Figure 6 and Appendix D.

In the initial counts of the alfalfa-orchardgrass mixture, more total plants per square foot (Figure 6) were counted where phosphorus was banded at the high rate and the nitrogen-potassium broadcast at the low level. Almost equally as good were treatments where phosphorus and nitrogen-potassium were both broadcast at the high or low rate or where no fertilizer was applied. The poorest alfalfa-orchardgrass stands occurred when both phosphorus and nitrogen-potassium were banded at

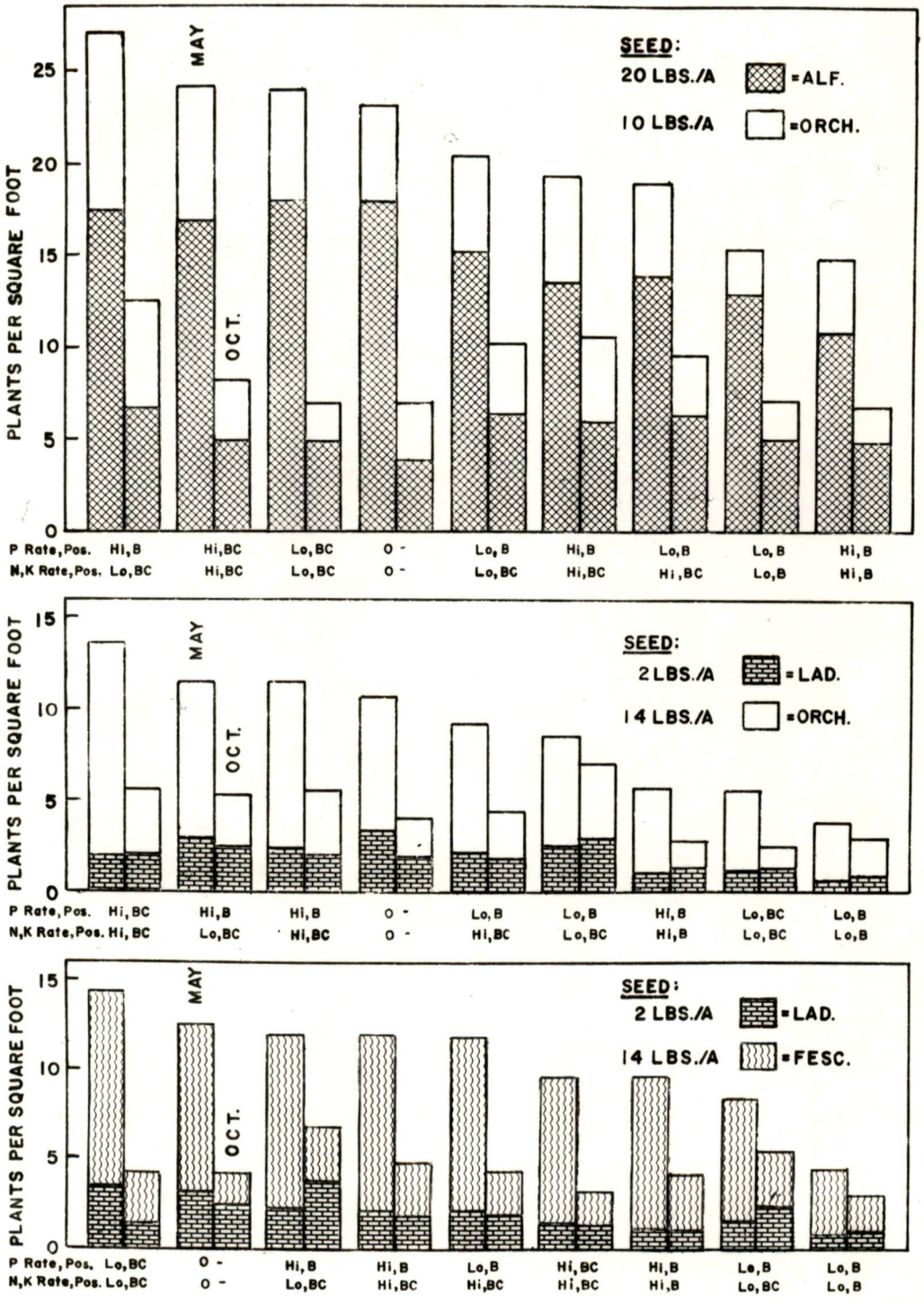

FIGURE **6.** EXPERIMENT 3. MAY AND OCTOBER 1957 STAND COUNTS OF ALFALFA-ORCHARDGRASS, LADINO-ORCHARDGRASS AND LADINO-FESCUE FOLLOWING SEEDING ON APRIL 13, 1957 WITH BANDED SEED AND WITH VARYING RATES AND POSITIONS OF PHOSPHORUS AND NITROGEN-POTASSIUM FERTILIZERS.

either high or low rate. These low stand counts reflected possible seed and seedling injury from a high concentration of fertilizer placed too close to the seed.

Final stands of the alfalfa-orchardgrass mixtures varied somewhat from the original stands. Even though the plots that received no fertilizer produced adequate stands at first, the survival was very poor, especially for alfalfa (Figure 6). No significant differences between treatments were obtained at the .05 level of probability for the alfalfa final counts but significant differences were obtained among the orchardgrass counts.

Even though differences in orchardgrass stand counts, in the orchardgrass-Ladino mixture, resulting from treatments were not significant at the .05 level of probability, it is of interest to note that these stand counts were arrayed in approximately the same order as the counts obtained for the orchardgrass in the alfalfa-orchardgrass mixture. Although Ladino clover stands were very poor, stand counts indicated that better initial stands were obtained where phosphorus was banded and the nitrogen-potassium broadcast than when both were banded or broadcast.

The Ladino-fescue mixtures reacted in much the same manner as the Ladino-orchardgrass mixtures. Again no significant differences occurred between treatments with respect to the fescue. In some cases a higher number of Ladino clover plants was recorded when final counts were made than at first stand counts. This probably resulted from delayed germination or the repeated counting of single Ladino clover stolons.

Experiment 4. This experiment was by far the best, with respect to stands obtained, of the four experiments seeded in the spring. Soil conditions were near optimum at the time of seeding and more uniform.

stands were obtained. Figure 7 and Appendix E give comparisons of various below, side-band placements of two rates of fertilizer with ordinary band and broadcast methods with two seeding mixtures involved.

The placement of the fertilizer band one inch below and two inches to the side generally resulted in better stands of both legumes and the associated orchardgrass. In some cases the one-inch below and one-inch to the side treatment proved to be equally as good as the one-inch below and two-inch to the side position. The fertilizer banded directly beneath the seed at one and one-half inches below and two and one-half inches below gave better stands at the low rate of fertilization, particularly with the legumes. The fertility level made little difference in the one and one-half inches below and two and one-half inches below treatments with respect to orchardgrass. The broadcast seed and fertilizer treatments resulted in fewer plants of all species than banded treatments. A comparison is given in Figure 8 of fertilizer banded at the low rate one inch below and two inches to the side with twenty pounds alfalfa and ten pounds orchardgrass versus fertilizer broadcast at the high rate with two pounds Ladino clover and fourteen pounds orchardgrass broadcast.

Final counts indicated that the side-band placement method was still superior, in most cases, to fertilizer banding directly below the seed or to broadcast application of both seed and fertilizer.

Fall Seedings at the Blount County Site

The original plans for the fall seedings included the same four experiments that had been sown in the spring, in order to compare differences due to seasonal variation. The latter part of August was very dry

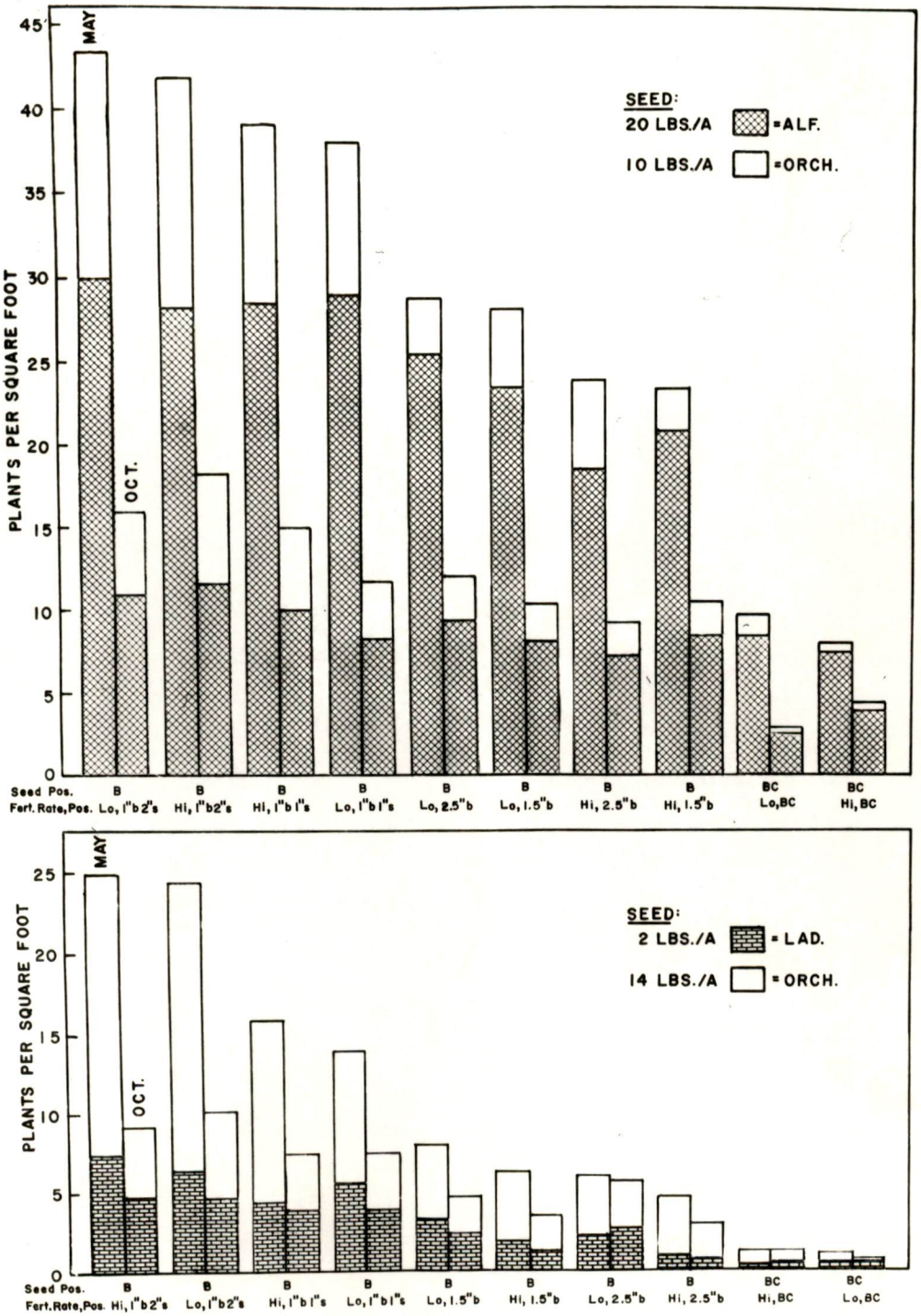

FIGURE 7. EXPERIMENT 4. MAY AND OCTOBER 1957 STAND COUNTS OF ALFALFA–ORCHARDGRASS AND LADINO–ORCHARDGRASS FOLLOWING SEEDING ON APRIL 16, 1957 WITH TWO FERTILIZATION RATES AND WITH VARIOUS DISTANCES BETWEEN SEED AND FERTILIZER.

Figure 8. Plot on left shows results of fertilizer banded at 15-60-60 pounds per acre, one inch below and two inches to the side of seed, with alfalfa seeded at 20 pounds per acre and orchardgrass at 10 pounds per acre. In the plot on right fertilizer was broadcast at 15-120-120 pounds per acre with 2 pounds Ladino clover per acre and 14 pounds orchardgrass per acre broadcast.

and hot; therefore seeding was postponed until approximately September 10, in the expectation that some rain and cooler weather would result in more favorable seeding conditions. When rains did start, much difficulty was encountered in selecting a time desirable for seeding. Experiments 1 and 2 were finally sown on September 27, with approximately two inches of rain falling immediately after seeding. Since seeding experiments 3 and 4 would have entailed later dates of seeding than those generally recommended, they were not sown.

Experiment 1. Appendix F shows the multiple range groups of counts taken approximately one month after seeding and again in February. Excellent initial stands were obtained as indicated by the number of plants per square foot. Approximately three times as many plants were counted as in the spring planting of the same experiment.

When the treatments are ranked in order of performance, the array obtained with the initial stand counts of the fall planting are somewhat reversed from those obtained with the spring seeding. The broadcast seed with broadcast or banded fertilizer plots produced a greater number of seedlings than when both seed and fertilizer were banded. Due to the high plant density, there was probably some seedling competition involved where the species were sown in rows above the fertilizer band, with such competition resulting in some reduction in stand. Blaser and McAuliffe (2) found that this happened when high rates of row-seeding were used. Here, where the seed was broadcast and the fertilizer banded, larger plants, which may be more vigorous than smaller plants, appeared directly over the band (Figure 9). Thatcher et al. (22) in Ohio, noted similar results when alfalfa was sown over a drilled band of phosphate fertilizer.

Figure 9. Plot on left illustrates the "banding effect" of banded fertilizer at 15-120-120 pounds per acre with 20 pounds alfalfa **per acre and 10 pounds orchardgrass per acre broadcast. The same rates** of seed and fertilizer were used in plot on right, but both seed and **fertilizer were banded.**

Second stand counts were taken on three replications of this experiment on February 11, 12 and 13, 1958. It was often difficult to determine which plants were living at the time the stand counts were made, in view of the severe heaving resulting from alternate freezing and thawing and extremely cold weather. A more accurate count will be possible when favorable growing conditions return and plant growth is resumed. Stands in most treatments were reduced severely, when February counts are compared to October counts (Appendix G). Survival figures indicate that stands of the broadcast-seeded plots were affected most by winter-kill. Several factors may have contributed to this. Initial establishment, in terms of plant vigor, was poorer. Combined root action was not as great in the broadcast plots as in the band-seeded plots, thus allowing more heaving and the formation of larger ice crystals or sheets on and between the plants of the broadcast plots. It is believed that later counts and observations will indicate better survival of the plants in the banded seed and banded fertilizer treatments or, in the case of the broadcast seed treatments, where the fertilizer was banded.

Fall Seedings at the Maury County Site

The Maury County experiments were irrigated three times, at weekly intervals after seeding, with approximately one inch of water at each application. When this is done, it is doubtful that band seeding is necessary to obtain adequate initial stands, although there may be some advantage when considering other aspects involved in stand establishment.

Experiments 5 and 6. Appendices H and I show the multiple range groups of treatments according to plants per square foot. In experiment

5, counts were proportional in most cases, to seeding rates. Little variation resulted from the method of seeding. Figure 10 illustrates the fact that excellent stands may be obtained by either band or broadcast methods of establishment when ideal moisture conditions are approached.

The addition of phosphorus to the fertilizer resulted in significantly fewer plants of both alfalfa and orchardgrass when the nitrogen and potassium were held constant (Experiment 5). In experiment 6, the addition of phosphorus did not produce as great a reduction when the same nitrogen and potassium treatments are compared with reference to placement.

Fall Seedings at the Robertson County Site

Experiment 7. The effects of varying fertilizer rates and fertilizer and seed positions on stand counts of Ladino and fescue are given in the multiple range tests in Appendix J.

No differences were obtained between treatments with respect to Ladino clover establishment, but differences were obtained when fescue was considered. The highest fescue counts were obtained where seed was banded and where fertilizer was banded two inches below seed at the high rate. The poorest stand occurred when the seed was broadcast and the fertilizer broadcast at the high rate (Figure 11). Other treatments produced stand counts that were not significantly different from each other.

Experiment 8. This experiment was essentially the same as experiment 7, but for the fact that a mixture of alsike clover and red clover was used with a lower rate of fescue (Appendix K). Total counts of the clovers were made, since it is difficult to distinguish between alsike and red clovers at this early stage of growth.

Figure 10. Plot on left illustrates results obtained when 20 pounds alfalfa per acre and 10 pounds orchardgrass per acre were broadcast with 15-0-120 pounds fertilizer per acre broadcast. The same rates of seed and fertilizer were used in plot on right but seed was banded with fertilizer banded one inch below and one inch to the side of seed.

Figure 11. Plot on left illustrates results obtained when 2 pounds Ladino clover per acre and 14 pounds fescue per acre were banded with 15-60-60 pounds fertilizer per acre banded one inch below and one inch to the side of seed. The right plot received the same seed broadcast with fertilizer broadcast at 15-120-120 pounds per acre.

No differences were obtained between clover counts when seed was banded or broadcast at low or high rates of fertilizer that was broadcast or placed one inch below and one inch to the side of the seed. These treatments resulted in larger stand counts than when the fertilizer was placed two inches below the seed at either high or low rate, the high rate being significantly better than the low rate.

The fescue in this experiment, as well as in experiment 7, did not respond in the same manner as the legumes with respect to seed placement and fertilizer rate and position. The highest fescue count was obtained where seed was banded and fertilizer banded two inches below the seed. Fertilizer placed one inch below and one inch to the side of the seed at the high rate of fertilizer proved to be almost as effective. The lowest count was obtained where seed was broadcast and fertilizer broadcast at the high rate.

General Discussion

Spring seedings were made in Blount County in mid-April. This is later than the recommended date. About a month of very dry weather ensued and this probably accounted, to a certain extent, for the poor stands obtained. A uniform, dense stand of crabgrass, Digitaria spp., germinated at the same time as the seedings over the entire experimental area resulting in uniformly severe competition as the season progressed. Haynes and Thatcher (14) and Wagner and Hulburt (26) have reported that banded plots were found to be less weedy than the broadcast plots. Forbes (9) has pointed out that results of that nature might be expected on low fertility soils. In Blount County, however, there was no particular

difference in the crabgrass infestation between the banded and the broadcast plots.

Seeding forage crops at a recommended time has long been recognized as an important factor in achieving successful seeding establishment. If the spring tests had been sown at an earlier date, environmental conditions might have been better for the crop species and less favorable for the crabgrass. Better stands might have been obtained from the seeded crops with less competition from the weeds.

The counts of treatment stands in spring-seeded experiments indicated that it was advantageous to band the seed and, in most cases, the fertilizer. When the fertilizer was banded beneath broadcast seed, the result was the same as that obtained when both seed and fertilizer were broadcast, i.e., practically no stands were obtained, probably as a consequence of insufficient moisture for initiating and sustaining germination and seedling growth. There was pronouncedly less stand in treatments where a high rate of fertilizer was banded directly beneath the seed than where the low rate of fertilizer was placed in a similar position. This was possibly due to the high salt concentration resulting from close proximity of the fertilizer to the germinating seeds or seedlings. As shown when the fertilizer was banded below and to the side of the seed, the side-placement method alleviated this effect. The fertilizer that was banded one inch below and two inches to the side of the seed was, in most cases, superior to that banded one inch below and one inch to the side, as measured by stand counts. Fertilizer placed in this manner apparently supplied the necessary nutrients without undue injury to seeds or seedlings. In the experiment where split applications of nitrogen and potassium, on

the one hand, and phosphorus fertilizers, on the other hand, were applied at different levels and placements, a reduction in stand occurred when all elements were banded as compared with other treatments. The reduction in stand was somewhat less severe when the nitrogen and potassium were broadcast at either high or low rate and the phosphorus was banded at either rate. Higher stand counts resulted when the nitrogen, potassium and phosphorus fertilizers were broadcast with the banded seed. This may be explained by the fact that the fertilizer was in contact with a greater soil mass and less injury to seeds and seedlings resulted from salt concentration. In the experiment to study the effects of seeding rate on forage establishment, where different species were seeded alone and in combinations, poor and uneven stands were obtained. The stands that were obtained were somewhat proportional to rates of seeding.

The fall seedings conducted in Blount, Maury and Robertson counties conformed more nearly to recommended dates of seeding than did the spring seedings. Adequate rainfall, or irrigation in the case of the Maury County tests, was available, and excellent stands were obtained on most treatments. Environmental conditions were not as favorable for the weed species as they had been in the spring-seeded tests and competition was not as important a factor.

The two tests that were repeated in Blount County resulted in much better stands than did the spring seedings. The manner in which the treatments ranked in the fall was almost the reverse of the ranking in the spring in experiment 1. When seed was broadcast, higher counts were obtained than when banded, regardless of how the fertilizer was applied or at what rate. The nature of the initial counts indicated that when

establishment conditions are favorable, excellent stands may be obtained from the broadcast method of forage establishment. The February counts did indicate that the picture may change after stands have been subjected to adverse winter weather conditions, especially after heaving caused by alternate freezing and thawing takes its toll. When October counts were made, the treatments that consisted of broadcast seed and banded fertilizer appeared almost as though the seed had been banded. The plants were taller and more vigorous directly over the fertilizer band. When February recordings were taken practically no plants existed between the fertilizer bands. The banding of both seed and fertilizer may prove to be effective in combating or alleviating the hazard of winter-killing. When species were seeded alone and in combination at different rates, in experiment 2, the stand counts obtained were proportional to rates of seeding.

In the Maury and Robertson County experiments, October counts only were made on the August seedings. At that time, there was a lush growth of vegetation at the Maury site (Figure 10). Stand counts were somewhat in proportion to seeding rates. The broadcasting of both seed and fertilizer proved to be as efficient as the various banding methods used. This might be expected, since irrigation was applied after seeding. The addition of phosphorus did not prove beneficial in the early stages of stand establishment. Actually, lower counts were obtained in most instances where phosphorus was not withheld from the fertilizer mixture, when neither nitrogen nor potassium was a variable. Even though the nitrogen and potassium salts are presumably the ones that cause the most seed and seedling damage, the addition of phosphorus may have increased the

concentration just enough to have caused a reduction in stand. It is possible that information of value may be obtained from the Maury County experiments in later stages of development. In the Robertson County tests, vegetative growth was much less than at the Maury County site. This was probably due to lower water availability on a different soil type, as well as to the fact that different species were involved. The side-band placements of fertilizer were no better in obtaining initial stands than the banding of fertilizer directly beneath the seed. Where there is adequate moisture to dilute the concentration of fertilizer, banding directly below the seed may be as effective as the side-band placement. The broadcasting of seed and the broadcasting of fertilizer at the high rate resulted in good stands of all species except the fescue. Since ryegrass was prevalent in these Robertson County experiments, some of the fescue plants may have been miscounted as ryegrass, resulting in a bias to the disadvantage of the fescue counts.

The present study, as well as other similar studies, have indicated that, although band seeding is not the answer to all forage establishment problems, it is probably one of the best techniques developed to-date. Band placement of seed and fertilizer has consistently given as good stands as, and often much better than, those obtained with conventional seeding methods. Until there is some practical means for controlling weeds in spring plantings, it may not be feasible, in many instances, to attempt establishment of permanent pasture species in the spring. Fall seedings have, thus far, proven to be more successful.

CHAPTER V

SUMMARY AND CONCLUSIONS

Due to the difficulty involved in the establishment of some small-seeded grasses and legumes, a series of experiments was initiated in the spring and fall in Blount County and in the fall in Maury and Robertson counties with the following objectives in mind: to study the effects on stand establishment of banded and broadcast fertilizer applied with various rates of banded and broadcast seed; to study competition effects between grasses and legumes when seeded alone and in combination at different rates when both seed and fertilizer are banded; to determine the separate effects on establishment of the placement of bands of nitrogen and potassium fertilizer and phosphorus fertilizer in relation to the placement of seed; and to determine the effect on seedling establishment of distance of fertilizer band from seed at different fertilization rates.

Stand counts were employed as a means of determining which treatments offer promise in successful forage establishment. It has been pointed out that information of value may be obtained in this manner without taking the experiment to later stages of plant development, although this will be desirable in subsequent years.

The following conclusions may be drawn from the data presented herein:

1. Better stands generally may be obtained in the spring when established by the band method especially when conditions are not optimum.

2. When the band method of seeding is employed, nitrogen, potassium and phosphorus fertilizers in combination should not be banded at high rates directly beneath the seed, but below and to the side, to prevent possible seed and seedling injury.

3. Stand counts obtained from the fall seedings indicate that when conditions are near optimum, the broadcast placement of seed and fertilizer will produce as high or higher initial stand counts as when both are banded.

4. When seed is broadcast over a band of fertilizer, taller, more vigorous plants are produced directly over the band.

5. Better winter survival may be obtained from fall seedings when both seed and fertilizer are banded.

6. Adherence to recommended dates of seeding is urged. However, if departure from the recommended dates of seeding is necessary, the band method of seeding forage species may make possible the successful establishment of small-seeded species when the use of customary practices might lead to failures.

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LITERATURE CITED

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APPENDICES

APPENDIX A

INCHES OF DAILY AND MONTHLY PRECIPITATION, U. S. WEATHER BUREAU, KNOXVILLE AIRPORT, AND MONTHLY PRECIPITATION, BLOUNT COUNTY FARM (1957)

Date	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.
1	.02	.45	.03			.22		.06	
2		.02	.23				.06	.06	
3							.04	1.35	.03
4	.04	1.62		.69		.96	.01	.49	
5	.03	.07		.35					
6	.12							.23	
7	.76								
8	.29	2.32		.01					
9				1.90			.10		.35
10							.03		
11			.23	.02			.45		
12	.40	.02		.03		.02	.18		
13		.01					1.85		.13
14	.09		.04	.05		.05	.19		.29
15	.03		.05		.14	.34	.10		.30
16				.15		.05	1.29	.01	1.48
17			.23	.35		1.20		.60	2.03
18	.14		.18		.01	.98	.10		.58
19			.28				.09		.06
20		.05					.13		
21	.10								
22	.08		.66	.01			.41		.66
23				.04	.36		.04	.31	.19
24	.13		1.40	1.79	.01			.10	.23
25						.25			1.06
26	.03		.05						
27				.06	.02		.56	.22	
28				.18	.02		.60		.06
29			.15				.73		
30				.23	.14		.02		
31		--		--			--		
Monthly total									
Airport	2.26	4.56	3.53	5.86	.70	4.07	6.98	3.43	7.45
Blount	----	----	3.30	5.84	.72	2.29	8.02	4.11	7.87

APPENDIX B

EXPERIMENT 1. ALFALFA AND ORCHARDGRASS STAND COUNTS ON VARIOUS 1957 DATES FOLLOWING SEEDING ON APRIL 15, 1957 IN BLOUNT COUNTY, WITH VARYING FERTILIZER AND SEED RATES AND POSITIONS

MULTIPLE RANGE GROUPS

Pounds Seed per Acre		Seed	Fertilizer		Plants per Sq. Ft.	Multiple Range Groups[b]
Alf.	Orch.	Pos.	Rate	Pos.	Alf. May 14-17, 1957	
20	10	B	Lo	BC	15.7[a]	
20	10	B	Hi	BC	14.7	
20	10	B	Lo	B	14.4	
10	5	B	Hi	BC	9.4	
10	5	B	Lo	B	8.5	
20	10	B	Hi	B	7.5	
10	5	B	Lo	B	7.4	
10	5	B	Hi	B	5.5	
20	10	BC	Lo	B	3.0	
20	10	BC	Lo	BC	2.9	
20	10	BC	Hi	BC	2.6	
10	5	BC	Lo	BC	2.2	
20	10	BC	Hi	B	2.1	
10	5	BC	Hi	BC	1.8	
10	5	BC	Lo	B	1.7	
10	5	BC	Hi	B	1.4	

[a] Each stand count reported represents the mean of 32 (6" x 18" quadrat) counts, 8 quadrats per plot on each of 4 replications.

[b] Any two means joined by the same line are not significantly different from each other at the .05 level of probability.

Pounds Seed per Acre		Seed	Fertilizer		Plants per sq. ft.	Multiple Range Groups[b/]
Alf.	Orch.	Pos.	Rate	Pos.	Orch. May 14-17, 1957	
20	10	B	Lo	BC	2.9	
20	10	B	Lo	B	2.5	
20	10	B	Hi	BC	2.4	
10	5	B	Hi	BC	1.8	
10	5	B	Lo	BC	.9	
10	5	B	Lo	B	.8	
10	5	B	Hi	B	.6	
20	10	B	Hi	B	.5	
10	5	BC	Hi	BC	.1	
20	10	BC	Hi	BC	.1	
10	5	BC	Lo	B	.1	
10	5	BC	Hi	B	.1	
20	10	BC	Lo	B	.1	
10	5	BC	Lo	BC	.1	
20	10	BC	Lo	BC	0.0	
20	10	BC	Hi	B	0.0	

Pounds Seed per Acre		Seed	Fertilizer		Plants per Sq. Ft.	Multiple Range Groups
Alf.	Orch.	Pos.	Rate	Pos.	Alf.	
					June 17, 1957	
20	10	B	Lo	B	13.4	
20	10	B	Lo	BC	12.4	
20	10	B	Hi	BC	12.4	
20	10	B	Hi	B	8.2	
10	5	B	Lo	B	7.1	
10	5	B	Hi	BC	6.8	
10	5	B	Lo	BC	6.3	
10	5	B	Hi	B	5.9	
20	10	BC	Hi	B	4.9	
20	10	BC	Hi	BC	4.6	
20	10	BC	Lo	BC	4.4	
20	10	BC	Lo	B	4.0	
10	5	BC	Lo	BC	3.1	
10	5	BC	Lo	B	2.5	
10	5	BC	Hi	BC	2.4	
10	5	BC	Hi	B	1.6	
					Orch. June 17, 1957	
20	10	B	Lo	B	3.8	
20	10	B	Lo	BC	3.5	
20	10	B	Hi	BC	2.6	
10	5	B	Lo	B	2.1	
20	10	BC	Lo	B	2.1	
10	5	B	Lo	BC	1.8	
20	10	B	Hi	B	1.7	
20	10	BC	Hi	BC	1.4	
10	5	B	Hi	BC	1.3	
20	10	BC	Lo	BC	.9	
10	5	BC	Hi	BC	.6	
10	5	B	Hi	B	.6	
20	10	BC	Hi	B	.5	
10	5	BC	Lo	BC	.4	
10	5	BC	Lo	B	.3	
10	5	BC	Hi	B	.1	

Pounds Seed per Acre		Seed	Fertilizer		Plants per Sq. Ft.	Multiple Range Groups
Alf.	Orch.	Pos.	Rate	Pos.	Alf.	
					Oct. 14, 1957	
20	10	B	Lo	BC	7.4	
20	10	B	Lo	B	6.6	
20	10	B	Hi	BC	4.4	
20	10	B	Hi	B	4.3	
10	5	B	Hi	B	4.2	
10	5	B	Lo	B	3.5	
10	5	B	Lo	B	3.3	
20	10	BC	Lo	B	2.5	
10	5	B	Hi	BC	2.5	
20	10	BC	Hi	B	2.2	
20	10	BC	Lo	BC	1.7	
20	10	BC	Hi	BC	1.6	
10	5	BC	Hi	BC	1.4	
10	5	BC	Lo	BC	.9	
10	5	BC	Lo	B	.9	
10	5	BC	Hi	B	.8	
					Orch.	
					Oct. 14, 1957	
20	10	B	Lo	B	2.0	
20	10	B	Lo	BC	1.6	
20	10	B	Hi	BC	.7	
10	5	B	Hi	B	.6	
10	5	B	Hi	BC	.4	
10	5	B	Lo	B	.2	
20	10	BC	Hi	BC	.1	
10	5	BC	Hi	BC	.1	
10	5	B	Lo	BC	.1	
20	10	B	Hi	B	.1	
20	10	BC	Lo	BC	.1	
10	5	BC	Lo	BC	0	
10	5	BC	Lo	B	0	
10	5	BC	Hi	B	0	
20	10	BC	Lo	B	0	
20	10	BC	Hi	B	0	

ANALYSES OF VARIANCE

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Alf. 14-17 May,1957		
Total	511		
Replications	3	11.0303	16.68**
Treatments	15	17.4308	26.35**
Reps. x Tmts.	45	.6614	1.58*
Quadrats	448	.4178	
	Orchardgrass 14-17 May, 1957		
Total	511		
Replications	3	.7994	2.51
Treatments	15	1.9333	6.07**
Reps. x Tmts.	45	.3187	1.91**
Quadrats	448	.1670	
	Alfalfa 17 June, 1957		
Total	511		
Replications	3	1.9809	1.74
Treatments	15	9.4507	8.31**
Reps. x Tmts.	45	1.1378	2.65**
Quadrats	448	.4291	
	Orchardgrass 17 June, 1957		
Total	511		
Replications	3	.5321	.95
Treatments	15	1.7980	3.23**
Reps. x Tmts.	45	.5574	1.95**
Quadrats	448	.2852	
	Alfalfa 14 October, 1957		
Total	511		
Replications	3	1.1140	2.04
Treatments	15	5.0446	9.22**
Reps. x Tmts.	45	.5473	2.37**
Quadrats	448	.2312	
	Orchardgrass 14 October, 1957		
Total	511		
Replications	3	.1944	.94
Treatments	15	.8329	4.02**
Reps. x Tmts.	45	.2073	3.57**
Quadrats	448	.0580	

APPENDIX C

EXPERIMENT 2. ALFALFA, LADINO CLOVER, ORCHARDGRASS AND FESCUE STAND COUNTS ON VARIOUS 1957 DATES FOLLOWING SEEDING ON APRIL 13, 1957 IN BLOUNT COUNTY WITH VARYING SEED RATES

MULTIPLE RANGE GROUPS

Lbs. Seed per Acre		Plants per sq. foot	Mult. Range	Lbs. Seed per Acre		Plants per sq. foot	Mult. Range
Alf.	Orch.	Alf.	Groups	Fesc.	Lad.	Fesc.	Groups
		May 15-18, 1957				May 15-18, 1957	
20	5	9.8		14	2	7.1	
20	--	8.0		14	--	6.6	
20	10	7.6		14	1	5.2	
10	5	6.7		7	1	3.3	
10	10	5.9		7	2	2.1	
		June 20, 1957				June 20, 1957	
20	5	7.9		14	2	8.5	
20	--	7.7		14	--	7.4	
20	10	7.1		14	1	6.1	
10	5	5.9		7	2	4.6	
10	10	5.0		7	1	4.0	
		Oct. 22-24, 1957				Oct. 22-24, 1957	
20	5	6.5		14	1	5.2	
10	5	5.9		14	--	4.5	
20	--	5.5		14	2	2.7	
20	10	5.5		7	2	2.3	
10	10	3.6		7	1	2.2	

Lbs. Seed per Acre			Pl. per sq. ft.	Mult. Range
Orch.	Lad.	Alf.	Orch.	Groups
		May 15-18, 1957		
14	1	--	4.4	
14	2	--	2.9	
14	--	--	2.7	
10	--	10	2.6	
7	1	--	2.4	
7	2	--	1.9	
5	--	10	1.7	
10	--	20	1.7	
5	--	20	1.4	
		June 20, 1957		
14	2	--	5.8	
14	--	--	4.8	
14	1	--	4.5	
7	2	--	3.7	
10	--	10	3.6	
10	--	20	3.5	
7	1	--	3.3	
5	--	10	2.8	
5	--	20	1.8	
		Oct. 22-24, 1957		
14	--	--	2.9	
14	2	--	2.6	
14	1	--	2.5	
10	--	10	2.2	
5	--	10	2.1	
5	--	20	1.8	
10	--	20	1.7	
7	1	--	1.7	
7	2	--	1.6	

Lbs. Seed per Acre			Pl.per sq.ft.	Mult. Range
Lad.	Fesc.	Orch.	Lad.	Groups
		May 15-18, 1957		
2	--	--	1.7	
2	7	--	1.3	
2	--	14	1.1	
2	14	--	1.0	
2	--	7	.8	
1	7	--	.5	
1	14	--	.4	
1	--	14	.2	
1	--	7	0.0	
		June 20, 1957		
2	--	--	1.4	
2	7	--	.8	
2	14	--	.7	
2	--	7	.6	
2	--	14	.6	
1	14	--	.5	
1	7	--	.3	
1	--	14	.1	
1	--	7	.1	
		Oct. 22-24, 1957		
2	--	--	3.4	
2	14	--	2.7	
2	7	--	2.2	
2	--	7	2.0	
1	7	--	1.2	
2	--	14	1.1	
1	--	14	.9	
1	--	7	.8	
1	14	--	.7	

ANALYSES OF VARIANCE

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Alfalfa 15-18 May, 1957		
Total	159		
Replications	3	2.5570	3.38*
Treatments	4	1.8328	2.42*
Reps. x Tmts.	12	1.0309	1.40
Quadrats	140	.7340	
Pooled error	152	.7574	
	20 June, 1957		
Total	159		
Replications	3	1.6376	3.05*
Treatments	4	1.3603	2.50*
Reps. x Tmts.	12	.9181	1.78
Quadrats	140	.5132	
Pooled error	152	.5451	
	22-24 October, 1957		
Total	159		
Replications	3	1.1013	1.00
Treatments	4	1.2160	1.10
Reps. x Tmts.	12	1.1022	3.58**
Quadrats	140	.3083	
	Fescue 15-18 May, 1957		
Total	159		
Replications	3	2.7226	4.01**
Treatments	4	5.0317	7.40**
Reps. x Tmts.	12	.7634	1.14
Quadrats	140	.6725	
Pooled error	152	.6797	
	20 June, 1957		
Total	159		
Replications	3	1.1808	2.92*
Treatments	4	2.6798	6.63**
Reps. x Tmts.	12	.7493	1.85
Quadrats	140	.3746	
Pooled error	152	.4042	

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	22-24 October, 1957		
Total	159		
Replications	3	1.6969	1.60
Treatments	4	2.2452	2.12
Reps. x Tmts.	12	1.0584	2.77**
Quadrats	140	.3824	
	Orchardgrass 15-18 May, 1957		
Total	287		
Replications	3	.7962	1.73*
Treatments	8	1.0988	2.39*
Reps. x Tmts.	24	.4809	1.05
Quadrats	252	.4579	
Pooled error	276	.4599	
	20 June, 1957		
Total	287		
Replications	3	1.3582	2.57
Treatments	4	1.2952	2.45*
Reps. x Tmts.	24	.6832	1.33
Quadrats	252	.5128	
Pooled error	276	.5276	
	22-24 October, 1957		
Total	287		
Replications	3	.7665	1.07
Treatments	8	.4297	.60
Reps. x Tmts.	24	.7190	3.01**
Quadrats	252	.2390	
	Ladino 15-18 May, 1957		
Total	287		
Replications	3	1.0909	7.25**
Treatments	8	.6459	4.29**
Reps. x Tmts.	24	.1505	.89
Quadrats	252	.1694	
Pooled error	276	.1315	

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	20 June, 1957		
Total	287		
Replications	3	.4043	2.64
Treatments	8	.4122	2.70*
Reps. x Tmts.	24	.1525	1.74*
Quadrats	252	.0875	
	22-24 October, 1957		
Total	287		
Replications	3	1.0325	4.20**
Treatments	8	1.4259	5.88**
Reps. x Tmts.	24	.3805	1.55
Quadrats	252	.2328	
Pooled error	276	.2456	

APPENDIX D

EXPERIMENT 3. ALFALFA, LADINO CLOVER, ORCHARDGRASS AND FESCUE STAND COUNTS ON VARIOUS 1957 DATES FOLLOWING SEEDING ON APRIL 13, 1957 IN BLOUNT COUNTY WITH VARYING RATES AND POSITIONS OF NITROGEN, POTASSIUM AND PHOSPHORUS FERTILIZERS

MULTIPLE RANGE GROUPS

Pounds per Acre P_2O_5 Rate	Pos.	Pounds per Acre N and K_2O Rate	Pos.	Pl.per sq. ft.	Mult. Range Groups
		Alf. May 14-17, 1957			
0	--	0	--	17.9[a]	
Lo	BC	Lo	BC	17.8	
Hi	B	Lo	BC	17.5	
Hi	BC	Hi	BC	16.8	
Lo	B	Lo	BC	15.1	
Lo	B	Hi	BC	13.9	
Hi	B	Hi	BC	13.5	
Lo	B	Lo	B	12.8	
Hi	B	Hi	B	10.7	
		Lad. May 14-17, 1957			
0	--	0	--	3.4	
Hi	B	Lo	BC	3.0	
Lo	B	Lo	BC	2.6	
Hi	B	Hi	BC	2.4	
Lo	B	Hi	BC	2.2	
Hi	BC	Hi	BC	1.9	
Lo	BC	Lo	BC	1.2	
Hi	B	Hi	B	1.1	
Lo	B	Lo	B	.6	
		Lad. May 14-17, 1957			
Lo	BC	Lo	BC	3.5	
0	--	0	--	3.2	
Hi	B	Lo	BC	2.3	
Lo	B	Hi	BC	2.2	
Hi	B	Hi	BC	2.2	
Lo	B	Lo	BC	1.6	
Hi	BC	Hi	BC	1.5	
Hi	B	Hi	B	1.2	
Lo	B	Lo	B	.8	

Pounds per Acre P_2O_5 Rate	Pos.	Pounds per Acre N and K_2O Rate	Pos.	Plants per sq. ft.	Mult. Range Groups
		Orch. May 14-17, 1957			
Hi	B	Lo	BC	9.5	
Hi	BC	Hi	BC	7.3	
Lo	BC	Lo	BC	6.0	
Hi	B	Hi	BC	5.8	
0	--	0	--	5.2	
Lo	B	Lo	BC	5.2	
Lo	B	Hi	BC	5.1	
Hi	B	Hi	B	4.1	
Lo	B	Lo	B	2.5	
		Orch. May 14-17, 1957			
Hi	BC	Hi	BC	11.7	
Hi	B	Hi	BC	9.1	
Hi	B	Lo	BC	8.5	
0	--	0	--	7.3	
Lo	B	Hi	BC	7.0	
Lo	B	Lo	BC	6.0	
Hi	B	Hi	B	4.6	
Lo	BC	Lo	BC	4.4	
Lo	B	Lo	B	3.2	
		Fesc. May 14-17, 1957			
Lo	BC	Lo	BC	10.8	
Hi	B	Hi	BC	9.8	
Lo	B	Hi	BC	9.7	
Hi	B	Lo	BC	9.7	
0	--	0	--	9.4	
Hi	B	Hi	B	8.4	
Hi	BC	Hi	BC	8.1	
Lo	B	Lo	BC	6.8	
Lo	B	Lo	B	3.7	

[a] Each stand count reported represents the mean of 32 (6" x 18") quadrat counts, 8 quadrats per plot on each of 4 replications.

Pounds per Acre P_2O_5 Rate	Pos.	Pounds per Acre N and K_2O Rate	Pos.	Plants per sq. ft.	Mult. Range Groups
		Alf. June 18-19, 1957			
0	--	0	--	12.0	
Hi	B	Hi	BC	11.1	
Lo	BC	Lo	BC	11.1	
Hi	B	Lo	BC	11.1	
Hi	BC	Hi	BC	10.5	
Lo	B	Lo	BC	10.1	
Lo	B	Hi	BC	9.1	
Lo	B	Lo	B	8.5	
Hi	B	Hi	B	8.5	
		Lad. June 18-19, 1957			
0	--	0	--	2.1	
Hi	B	Hi	BC	1.9	
Lo	B	Lo	BC	1.8	
Lo	B	Hi	BC	1.8	
Hi	B	Lo	BC	1.8	
Hi	BC	Hi	BC	1.4	
Hi	B	Hi	B	1.2	
Lo	BC	Lo	BC	1.1	
Lo	B	Lo	B	.6	
		Lad. June 18-19, 1957			
0	--	0	--	2.6	
Lo	B	Hi	BC	2.3	
Hi	B	Hi	BC	2.1	
Lo	BC	Lo	BC	2.1	
Hi	B	Lo	BC	2.1	
Lo	B	Lo	BC	2.0	
Lo	B	Lo	B	1.1	
Hi	BC	Hi	BC	1.0	
Hi	B	Hi	B	.8	
		Orch. June 18-19, 1957			
Hi	B	Lo	BC	8.3	
Hi	B	Hi	B	5.6	
Hi	BC	Hi	BC	5.3	
Hi	B	Hi	BC	5.2	
Lo	B	Lo	BC	4.4	
Lo	B	Hi	BC	4.2	
0	--	0	--	4.2	
Lo	BC	Lo	BC	3.8	
Lo	B	Lo	B	3.2	
		Orch. June 18-19, 1957			
Hi	BC	Hi	BC	8.8	
Hi	B	Hi	BC	8.2	
Hi	B	Hi	B	7.2	
Lo	B	Hi	BC	6.2	
Hi	B	Lo	BC	5.4	
Lo	B	Lo	BC	5.2	
0	--	0	--	3.9	
Lo	B	Lo	B	3.3	
Lo	BC	Lo	BC	2.4	
		Fesc. June 18-19, 1957			
Lo	B	Hi	BC	7.3	
Hi	B	Lo	BC	7.2	
Hi	B	Hi	BC	7.0	
Lo	B	Lo	BC	6.6	
Hi	B	Hi	B	6.6	
Lo	BC	Lo	BC	6.3	
Hi	BC	Hi	BC	6.0	
0	--	0	--	5.8	
Lo	B	Lo	B	5.5	

Pounds per Acre				Plants per sq. ft.	Mult. Range Groups
P_2O_5 Rate	Pos.	N and K_2O Rate	Pos.		
		Alf. Oct. 21-22, 1957			
Hi	B	Lo	BC	6.7	
Lo	B	Hi	BC	6.3	
Lo	B	Lo	BC	6.3	
Hi	B	Hi	BC	6.0	
Lo	B	Lo	B	5.1	
Lo	BC	Lo	BC	4.9	
Hi	BC	Hi	BC	4.9	
Hi	B	Hi	B	4.8	
0	--	0	--	3.9	
		Lad. Oct. 21-22, 1957			
Lo	B	Lo	BC	3.0	
Hi	B	Lo	BC	2.5	
Hi	BC	Hi	BC	2.1	
Hi	B	Hi	BC	2.0	
0	--	0	--	1.9	
Lo	B	Hi	BC	1.8	
Lo	BC	Lo	BC	1.3	
Hi	B	Hi	B	1.3	
Lo	B	Lo	B	.8	
		Lad. Oct. 21-22, 1957			
Hi	B	Lo	BC	3.8	
0	--	0	--	2.5	
Lo	B	Lo	BC	2.5	
Lo	B	Hi	BC	2.0	
Hi	B	Hi	BC	1.9	
Lo	BC	Lo	BC	1.4	
Hi	BC	Hi	BC	1.4	
Lo	B	Lo	B	1.1	
Hi	B	Hi	B	1.1	

Pounds per Acre				Plants per sq.ft.	Mult. Range Groups
P_2O_5 Rate	Pos.	N and K_2O Rate	Pos.		
		Orch. Oct. 21-22, 1957			
Hi	B	Lo	BC	5.8	
Hi	B	Hi	BC	4.6	
Lo	B	Lo	BC	3.9	
Lo	B	Hi	BC	3.3	
Hi	BC	Hi	BC	3.2	
0	--	0	--	3.1	
Lo	B	Lo	B	2.1	
Lo	BC	Lo	BC	2.0	
Hi	B	Hi	B	1.9	
		Orch. Oct. 21-22, 1957			
Lo	B	Lo	BC	4.1	
Hi	B	Hi	BC	3.6	
Hi	BC	Hi	BC	3.5	
Hi	B	Lo	BC	2.8	
Lo	B	Hi	BC	2.8	
Lo	B	Lo	B	2.2	
0	--	0	--	2.2	
Hi	B	Hi	B	1.4	
Lo	BC	Lo	BC	1.3	
		Fesc. Oct. 21-22, 1957			
Hi	B	Hi	B	3.1	
Lo	B	Lo	BC	3.1	
Hi	B	Hi	BC	2.9	
Hi	B	Lo	BC	2.9	
Lo	BC	Lo	BC	2.8	
Lo	B	Hi	BC	2.4	
Lo	B	Lo	B	2.0	
Hi	BC	Hi	BC	1.8	
0	--	0	--	1.7	

ANALYSES OF VARIANCE

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Alfalfa 14-17 May, 1957		
Total	287		
Replications	3	5.8022	3.02*
Treatments	8	4.7189	2.45*
Reps. x Tmts.	24	1.9244	2.58**
Quadrats	252	.7469	
	Orchardgrass 14-17 May, 1957		
Total	287		
Replications	3	1.5243	1.25
Treatments	8	4.0952	3.36**
Reps. x Tmts.	24	1.2177	1.84*
Quadrats	252	.6601	
	Ladino 14-17 May, 1957		
Total	287		
Replications	3	3.7283	7.03**
Treatments	8	1.3365	2.52*
Reps. x Tmts.	24	.5301	1.96**
Quadrats	252	.2698	
	Orchardgrass 14-17 May, 1957		
Total	287		
Replications	3	8.5750	2.62
Treatments	8	4.3047	1.32
Reps. x Tmts.	24	3.2724	3.60**
Quadrats	252	.9088	
	Ladino 14-17 May, 1957		
Total	287		
Replications	3	.9266	1.94
Treatments	8	1.2926	2.71*
Reps. x Tmts.	24	.4762	1.78*
Quadrats	252	.2674	
	Fescue 14-17 May, 1957		
Total	287		
Replications	3	2.4058	.93
Treatments	8	1.8715	.73
Reps. x Tmts.	24	2.5774	2.46**
Quadrats	252	1.0459	

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Alfalfa 18-19 June, 1957		
Total	287		
Replications	3	.7954	1.71
Treatments	8	1.1136	2.39*
Reps. x Tmts.	24	.3295	.69
Quadrats	252	.4779	
Pooled error	276	.4650	
	Orchardgrass 18-19 June, 1957		
Total	287		
Replications	3	.2679	.49
Treatments	8	1.9426	3.54**
Reps. x Tmts.	24	.6590	1.22
Quadrats	252	.5385	
Pooled error	276	.5489	
	Ladino 18-19 June, 1957		
Total	287		
Replications	3	.4292	.98
Treatments	8	.4669	1.07
Reps. x Tmts.	24	.4382	2.48**
Quadrats	252	.1768	
	Orchardgrass 18-19 June, 1957		
Total	287		
Replications	3	9.4829	4.53**
Treatments	8	3.7815	1.81*
Reps. x Tmts.	24	2.0915	3.15**
Quadrats	252	.6646	
	Ladino 18-19 June, 1957		
Total	287		
Replications	3	1.1868	5.35**
Treatments	8	.7184	3.24**
Reps. x Tmts.	24	.2118	.95
Quadrats	252	.2228	
Pooled error	276	.2218	
	Fescue 18-19 June, 1957		
Total	287		
Replications	3	3.1207	7.37**
Treatments	8	.4127	.97
Reps. x Tmts.	24	.4308	1.02
Quadrats	252	.4235	
Pooled error	276	.4241	

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Alfalfa 22-24 October, 1957		
Total	287		
Replications	3	1.0052	1.35
Treatments	8	.9265	1.25
Reps. x Tmts.	24	.7431	2.41**
Quadrats	252	.3079	
	Orchardgrass 22-24 October, 1957		
Total	287		
Replications	3	1.3794	1.85
Treatments	8	2.3090	3.10*
Reps. x Tmts.	24	.7439	2.06**
Quadrats	252	.3613	
	Ladino 22-24 October, 1957		
Total	287		
Replications	3	4.5953	12.25**
Treatments	8	.7491	2.00
Reps. x Tmts.	24	.3752	1.60*
Quadrats	252	.2340	
	Orchardgrass 22-24 October, 1957		
Total	287		
Replications	3	6.1158	7.36**
Treatments	8	1.2948	1.56
Reps. x Tmts.	24	.8308	2.84**
Quadrats	252	.2930	
	Ladino 22-24 October, 1957		
Total	287		
Replications	3	2.1350	5.63**
Treatments	8	1.3378	3.53**
Reps. x Tmts.	24	.3791	1.74*
Quadrats	252	.2021	
	Fescue 22-24 October, 1957		
Total	287		
Replications	3	2.0792	2.32
Treatments	8	.4746	.53
Reps. x Tmts.	24	.8980	2.77**
Quadrats	252	.3238	

APPENDIX E

EXPERIMENT 4. ALFALFA-ORCHARDGRASS AND LADINO CLOVER-ORCHARDGRASS STAND COUNTS ON VARIOUS 1957 DATES FOLLOWING SEEDING ON APRIL 16, 1957 IN BLOUNT COUNTY WITH TWO FERTILIZATION RATES AND WITH VARIOUS DISTANCES BETWEEN SEED AND FERTILIZER

MULTIPLE RANGE GROUPS

Fert. Pos. Below Seed	Fert. Pos. Side Seed	Fert. Rate	Plants per sq.ft.	Mult. Range Groups	Fert. Pos. Below Seed	Fert. Pos. Side Seed	Fert. Rate	Plants per sq.ft.	Mult. Range Groups
Seeding: twenty pounds per acre alfalfa, ten pounds per acre orchardgrass									
Alfalfa 13-16 May, 1957					Orchardgrass 13-16 May, 1957				
1"	2"	Lo	30.0[a/]		1"	2"	Hi	13.6	
1"	1"	Lo	29.0		1"	2"	Lo	13.3	
1"	1"	Hi	28.5		1"	1"	Hi	10.7	
1"	2"	Hi	28.2		1"	1"	Lo	9.2	
2½"	0	Lo	25.4		2½"	0	Hi	5.3	
1½"	0	Lo	23.4		1½"	0	Lo	4.7	
1½"	0	Hi	20.7		2½"	0	Lo	3.4	
2½"	0	Hi	18.5		1½"	0	Hi	2.6	
0	BC	Lo	8.4		0	BC	Lo	1.3	
0	BC	Hi	7.4		0	BC	Hi	.6	
Seeding: two pounds per acre ladino, fourteen pounds per acre orchardgrass									
Ladino 13-16 May, 1957					Orchardgrass 13-16 May, 1957				
1"	2"	Hi	7.3		1"	2"	Lo	18.0	
1"	2"	Lo	6.4		1"	2"	Hi	17.5	
1"	1"	Lo	5.6		1"	1"	Hi	11.5	
1"	1"	Hi	4.4		1"	1"	Lo	8.3	
1½"	0	Lo	3.2		1½"	0	Hi	5.1	
2½"	0	Lo	2.2		1½"	0	Lo	4.6	
1½"	0	Hi	1.7		2½"	0	Lo	3.7	
2½"	0	Hi	.9		2½"	0	Hi	3.7	
0	BC	Lo	.3		0	BC	Hi	1.0	
0	BC	Hi	.2		0	BC	Lo	.8	

a/ Each stand count reported represents the mean of 32 (6" x 18" quadrat) counts, 8 quadrats per plot each of 4 replications.

Fert. Pos. Below Seed	Fert. Pos. Side Seed	Fert. Rate	Plants per sq.ft.	Mult. Range Groups	Fert. Pos. Below Seed	Fert. Pos. Side Seed	Fert. Rate	Plants per sq.ft.	Mult. Range Groups
Seeding: Twenty pounds per acre alfalfa, ten pounds per acre orchardgrass									
	Alfalfa 21 June, 1957					Orchardgrass 21 June, 1957			
1"	2"	Lo	22.1		1"	2"	Hi	7.9	
1"	2"	Hi	21.3		1"	2"	Lo	7.3	
2½"	0	Lo	19.8		1"	1"	Lo	6.0	
1"	1"	Hi	18.0		1"	1"	Hi	6.0	
1"	1"	Lo	16.3		2½"	0	Hi	5.1	
1½"	0	Hi	15.3		1½"	0	Hi	4.4	
2½"	0	Hi	15.2		1½"	0	Lo	3.9	
1½"	0	Lo	14.8		2½"	0	Lo	3.1	
0	BC	Lo	14.2		0	BC	Hi	1.6	
0	BC	Hi	14.1		0	BC	Lo	1.2	
Seeding: Two pounds per acre ladino, fourteen pounds per acre orchardgrass									
	Ladino 21 June, 1957					Orchardgrass 21 June, 1957			
1"	2"	Lo	5.0		1"	2"	Lo	8.9	
1"	2"	Hi	4.4		1"	2"	Hi	7.9	
1"	1"	Lo	3.2		2½"	0	Hi	5.2	
1"	1"	Hi	2.3		1"	1"	Lo	4.4	
1½"	0	Lo	2.3		1½"	0	Lo	4.2	
2½"	0	Lo	1.9		1"	1"	Hi	4.0	
1½"	0	Hi	1.2		1½"	0	Hi	2.5	
0	BC	Hi	.9		2½"	0	Lo	2.3	
2½"	0	Hi	.8		0	BC	Lo	2.2	
0	BC	Lo	.5		0	BC	Hi	1.7	

Fert. Pos. Below Seed	Fert. Pos. Side Seed	Fert. Rate	Plants per sq.ft.	Mult. Range Groups	Fert. Pos. Below Seed	Fert. Pos. Side Seed	Fert. Rate	Plants per sq.ft.	Mult. Range Groups
Seeding: Twenty pounds per acre alfalfa, ten pounds per acre orchardgrass									
	Alfalfa 18 July, 1957					Orchardgrass 18 July, 1957			
1"	2"	Lo	20.1		1"	2"	Hi	7.9	
1"	1"	Hi	19.3		1"	2"	Lo	7.5	
1"	2"	Hi	16.2		1"	1"	Hi	6.7	
2½"	0	Lo	16.1		1"	1"	Lo	5.5	
1"	1"	Lo	16.0		2½"	0	Hi	4.0	
1½"	0	Hi	14.9		1½"	0	Hi	4.0	
1½"	0	Lo	14.6		1½"	0	Lo	3.7	
2½"	0	Hi	14.3		2½"	0	Lo	3.4	
0	BC	Hi	5.7		0	BC	Lo	.8	
0	BC	Lo	4.4		0	BC	Hi	.7	
Seeding: Two pounds per acre Ladino, fourteen pounds per acre orchardgrass									
	Ladino 18 July, 1957					Orchardgrass 18 July, 1957			
1"	2"	Hi	4.1		1"	2"	Hi	8.2	
1"	2"	Lo	3.5		1"	2"	Lo	6.9	
1"	1"	Lo	3.2		1"	1"	Hi	5.3	
1"	1"	Hi	2.4		1"	1"	Lo	5.0	
1½"	0	Lo	1.8		1½"	0	Lo	4.6	
2½"	0	Lo	1.8		1½"	0	Hi	3.9	
1½"	0	Hi	1.3		2½"	0	Lo	3.5	
2½"	0	Hi	.6		2½"	0	Hi	3.3	
0	BC	Hi	.5		0	BC	Hi	1.6	
0	BC	Lo	.4		0	BC	Lo	1.3	

Fert. Pos. Below Seed	Fert. Pos. Side Seed	Fert. Rate	Plants per sq.ft.	Mult. Range Groups	Fert. Pos. Below Seed	Fert. Pos. Side Seed	Fert. Rate	Plants per sq.ft.	Mult. Range Groups
Seeding: Twenty pounds per acre alfalfa, ten pounds per acre orchardgrass									
	Alfalfa 15-16 Oct., 1957					**Orchardgrass 15-16 Oct., 1957**			
1"	2"	Hi	11.6		1"	2"	Hi	6.6	
1"	2"	Lo	10.9		1"	1"	Hi	5.0	
1"	1"	Hi	10.0		1"	2"	Lo	4.9	
2½"	0	Lo	9.3		1"	1"	Lo	3.5	
1½"	0	Hi	8.4		2½"	0	Lo	2.7	
1"	1"	Lo	8.2		1½"	0	Lo	2.2	
1½"	0	Lo	8.1		1½"	0	Hi	2.1	
2½"	0	Hi	7.2		2½"	0	Hi	2.0	
0	BC	Hi	3.8		0	BC	Hi	.5	
0	BC	Lo	2.5		0	BC	Lo	.3	
Seeding: Two pounds per acre Ladino, fourteen pounds per acre orchardgrass									
	Ladino 15-16 Oct., 1957					**Orchardgrass 15-16 Oct., 1957**			
1"	2"	Hi	4.7		1"	2"	Lo	5.5	
1"	2"	Lo	4.6		1"	2"	Hi	4.4	
1"	1"	Lo	3.8		1"	1"	Lo	3.6	
1"	1"	Hi	3.2		1"	1"	Hi	3.1	
2½"	0	Lo	2.7		2½"	0	Lo	3.0	
1½"	0	Lo	2.4		1½"	0	Hi	2.3	
1½"	0	Hi	1.2		1½"	0	Lo	2.3	
2½"	0	Hi	.7		2½"	0	Hi	2.3	
0	BC	Hi	.5		0	BC	Hi	.7	
0	BC	Lo	.4		0	BC	Lo	.2	

ANALYSES OF VARIANCE

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
Alfalfa 13-16 May, 1957			
Total	319		
Replications	3	8.7527	7.98**
Treatments	9	21.7853	19.87**
Reps. x Tmts.	27	1.0966	1.76*
Quadrats	280	.6401	
Orchardgrass 13-16 May, 1957			
Total	319		
Replications	3	13.4751	8.79**
Treatments	9	16.4359	10.72**
Reps. x Tmts.	27	1.5337	2.03**
Quadrats	280	.7570	
Ladino 13-16 May, 1957			
Total	319		
Replications	3	3.5993	11.20**
Treatments	9	9.5999	29.87**
Reps. x Tmts.	27	.2171	.65
Quadrats	280	.3313	
Pooled error	307	.3213	
Orchardgrass 13-16 May, 1957			
Total	319		
Replications	3	7.3573	8.45**
Treatments	9	22.7977	26.19
Reps. x Tmts.	27	.5250	.58
Quadrats	280	.9038	
Pooled error	307	.8705	

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Alfalfa 21 June, 1957		
Total	319		
Replications	3	3.7038	3.52*
Treatments	9	18.6928	17.78**
Reps. x Tmts.	27	1.0513	2.59**
Quadrats	280	.4063	
	Orchardgrass 21 June, 1957		
Total	319		
Replications	3	5.1378	11.21**
Treatments	9	5.4352	11.86**
Reps. x Tmts.	27	.6547	1.43
Quadrats	280	.4391	
Pooled error	307	.4580	
	Ladino 21 June, 1957		
Total	319		
Replications	3	.5843	1.30
Treatments	9	3.4666	8.21**
Reps. x Tmts.	27	.4223	1.69*
Quadrats	280	.2502	
	Orchardgrass 21 June, 1957		
Total	319		
Replications	3	3.9623	2.79*
Treatments	9	4.3653	3.08*
Reps. x Tmts.	27	1.4180	2.43**
Quadrats	280	.5025	

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Alfalfa 18 July, 1957		
Total	319		
Replications	3	3.2299	3.39*
Treatments	9	13.0489	13.69**
Reps. x Tmts.	27	.9530	2.40**
Quadrats	280	.3965	
	Orchardgrass 18 July, 1957		
Total	319		
Replications	3	4.6045	9.45**
Treatments	9	7.0812	4.53**
Reps. x Tmts.	27	.5848	1.22
Quadrats	280	.4780	
Pooled error	307	.4874	
	Ladino 18 July, 1957		
Total	319		
Replications	3	.4687	1.73
Treatments	9	3.3264	12.26**
Reps. x Tmts.	27	.2712	1.67*
Quadrats	280	.1627	
	Orchardgrass 18 July, 1957		
Total	319		
Replications	3	6.5831	9.08**
Treatments	9	4.6892	6.47**
Reps. x Tmts.	27	1.0430	1.50
Quadrats	280	.6945	
Pooled error	307	.7251	

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Alfalfa 15-16 October, 1957		
Total	319		
Replications	3	3.2139	10.46**
Treatments	9	6.7259	21.89**
Reps. x Tmts.	27	.4303	1.46
Quadrats	280	.2953	
Pooled error	307	.3072	
	Orchardgrass 15-16 October, 1957		
Total	319		
Replications	3	3.7835	5.60**
Treatments	9	5.3167	7.88**
Reps. x Tmts.	27	.6751	2.33**
Quadrats	280	.2898	
	Ladino 15-16 October, 1957		
Total	319		
Replications	3	.4376	.45
Treatments	9	4.3277	4.46**
Reps. x Tmts.	27	.9703	4.12**
Quadrats	280	.2352	
	Orchardgrass 15-16 October, 1957		
Total	319		
Replications	3	9.2540	13.56**
Treatments	9	3.2305	4.73**
Reps. x Tmts.	27	.6827	1.75*
Quadrats	280	.3902	

APPENDIX F

EXPERIMENT 1. ALFALFA AND ORCHARDGRASS STAND COUNTS IN OCTOBER, 1957 AND FEBRUARY, 1958, FOLLOWING SEEDING ON SEPTEMBER 27, 1957 IN BLOUNT COUNTY WITH VARYING FERTILIZER AND SEED RATES AND POSITIONS

MULTIPLE RANGE GROUPS

Pounds Seed per Acre		Seed	Fertilizer		Plants per	Multiple Range
Alf.	Orch.	Pos.	Rate	Pos.	sq. ft.	Groups
					Alf. Oct. 25, 1957	
20	10	BC	Lo	BC	44.1[a/]	
20	10	BC	Hi	BC	41.6	
20	10	BC	Lo	B	34.7	
20	10	BC	Hi	B	33.8	
20	10	B	Hi	BC	21.6	
20	10	B	Hi	B	20.9	
10	5	BC	Lo	B	20.9	
10	5	BC	Hi	BC	20.8	
10	5	BC	Hi	B	19.4	
10	5	BC	Lo	BC	18.8	
20	10	B	Lo	BC	17.9	
10	5	B	Hi	BC	16.4	
20	10	B	Lo	B	15.8	
10	5	B	Lo	BC	14.4	
10	5	B	Hi	B	14.2	
10	5	B	Lo	B	12.8	
					Orch. Oct. 25, 1957	
20	10	BC	Hi	BC	21.7	
20	10	BC	Hi	B	21.0	
20	10	BC	Lo	B	17.3	
20	10	BC	Lo	BC	17.2	
10	5	BC	Hi	B	14.4	
20	10	B	Hi	BC	13.1	
10	5	BC	Hi	BC	12.0	
10	5	BC	Lo	BC	11.5	
20	10	B	Hi	B	10.6	
20	10	B	Lo	BC	10.3	
10	5	B	Lo	BC	9.8	
20	10	B	Lo	B	9.3	
10	5	B	Hi	BC	8.7	
10	5	BC	Lo	B	8.5	
10	5	B	Hi	B	8.3	
10	5	B	Lo	B	8.3	

a/ Each stand count reported represents the mean of 32 (6" x 18" quadrat) counts, 8 quadrats per plot on each of 4 replications.

Pounds Seed per Acre		Seed	Fertilizer		Plants per	Mult. Range	Percent Survival
Alf.	Orch.	Pos.	Rate	Pos.	sq.ft.	Groups	2nd count of 1st
					Alf.		
					Feb.11-13, 1958		
20	10	BC	Lo	BC	18.7[a]		42
20	10	BC	Hi	BC	16.4		39
20	10	BC	Hi	B	16.4		48
20	10	BC	Lo	B	13.4		39
10	5	B	Hi	B	13.2		93
20	10	B	Hi	B	11.4		55
20	10	B	Hi	BC	10.7		50
10	5	B	Lo	B	10.3		80
10	5	BC	Hi	BC	10.0		48
20	10	B	Lo	BC	9.5		53
10	5	BC	Hi	B	9.4		48
20	10	B	Lo	B	9.1		58
10	5	BC	Lo	B	7.8		37
10	5	B	Hi	BC	7.2		44
10	5	B	Lo	BC	6.8		47
10	5	BC	Lo	BC	6.7		35
					Orch.		
					Feb.11-13, 1958		
20	10	BC	Hi	BC	11.8		54
20	10	BC	Lo	BC	11.6		67
20	10	B	Hi	B	11.1		105
20	10	B	Hi	BC	10.4		79
10	5	B	Hi	B	9.1		110
10	5	BC	Hi	BC	7.8		65
10	5	B	Lo	B	7.4		89
20	10	BC	Lo	B	7.4		43
20	10	BC	Hi	B	7.4		35
20	10	B	Lo	B	6.8		73
20	10	B	Lo	BC	6.4		62
10	5	B	Lo	BC	6.2		63
10	5	B	Hi	BC	5.1		59
10	5	BC	Hi	B	4.7		33
10	5	BC	Lo	BC	4.6		40
10	5	BC	Lo	B	2.4		28

[a] Each stand count reported represents the mean of 24 (6" x 18" quadrat) counts, 8 quadrats per plot on each of 3 replications.

ANALYSES OF VARIANCE

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Alfalfa 25 Oct., 1957		
Total	511		
Replications	3	89.00	3.66*
Treatments	15	1394.60	57.30**
Reps. x Tmts.	45	22.09	.74
Quadrats	448	30.00	
Pooled error	493	24.34	
	Orchardgrass 25 Oct., 1957		
Total	511		
Replications	3	14.00	.67
Treatments	15	283.20	13.56**
Reps. x Tmts.	45	20.89	1.45*
Quadrats	448	14.43	
	Alfalfa 11-13 Feb., 1958		
Total	383		
Replications	2	241.00	16.53**
Treatments	15	141.53	9.71**
Reps. x Tmts.	30	18.40	1.29
Quadrats	336	14.24	
Pooled error	366	14.58	
	Orchardgrass 11-13 Feb., 1958		
Total	383		
Replications	2	151.00	10.39**
Treatments	15	79.13	5.45**
Reps. x Tmts.	30	14.53	1.51*
Quadrats	336	9.61	

APPENDIX G

EXPERIMENT 2. OCTOBER, 1957 STAND COUNTS OF ALFALFA, LADINO CLOVER, ORCHARDGRASS AND FESCUE FOLLOWING SEEDING ON SEPTEMBER 27, 1957 IN BLOUNT COUNTY WITH VARYING SEED RATES

MULTIPLE RANGE GROUPS

Pounds Seed per Acre		Plants per sq. ft.	Mult. Range Groups	Pounds Seed per Acre		Plants per sq. ft.	Mult. Range Groups
Alf.	Orch.			Fesc.	Lad.		
		Alfalfa Oct. 29, 1957				Fescue Oct. 29, 1957	
20	--	13.9[a/]		14	--	38.0	
20	5	12.7	|	14	1	33.1	|
20	10	12.6	|	14	2	30.9	
10	10	6.7		7	2	21.1	|
				7	1	19.6	|

Orch.	Lad.	Alf.	Orch. Oct. 29, 1957		Lad.	Fesc.	Lad. Orch.	Oct. 29, 1957	
14	--	--	34.7		2	--	--	20.1	
14	1	--	27.4	|	2	7	--	15.0	|
14	2	--	25.9	|	2	14	--	13.6	|
7	1	--	21.6		2	--	7	11.7	|
7	2	--	14.1	|	2	--	14	10.5	|
10	--	10	12.2	| |	1	7	--	8.9	|
10	--	20	11.2	|	1	--	7	7.7	|
5	--	20	5.5		1	14	--	5.4	|
					1	--	14	4.7	|

[a/] Each stand count reported represents the mean of 32 (6" x 18" quadrat) counts, 8 quadrats per plot on each of 4 replications.

ANALYSES OF VARIANCE

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Alfalfa 29 Oct., 1957		
Total	127		
Replications	3	20.33	1.37
Treatments	3	148.33	10.02**
Reps. x Tmts.	9	20.66	1.44
Quadrats	112	14.33	
Pooled error	121	14.80	
	Fescue 29 Oct., 1957		
Total	159		
Replications	3	176.00	3.54*
Treatments	4	899.00	18.09**
Reps. x Tmts.	12	75.33	1.59
Quadrats	140	47.47	
Pooled error	152	49.67	
	Orchardgrass 29 Oct., 1957		
Total	255		
Replications	3	18.67	.35
Treatments	7	1384.28	26.09**
Reps. x Tmts.	21	53.05	2.45**
Quadrats	224	21.62	
	Ladino 29 Oct., 1957		
Total	287		
Replications	3	5.67	.21
Treatments	8	342.75	12.88**
Reps. x Tmts.	24	26.62	1.98
Quadrats	252	13.44	

APPENDIX H

EXPERIMENT 5. OCTOBER, 1957 STAND COUNTS OF ALFALFA AND ORCHARDGRASS FOLLOWING SEEDING ON AUGUST 21, 1957 IN MAURY COUNTY WITH VARYING FERTILIZER AND SEED RATES AND PLACEMENTS

MULTIPLE RANGE GROUPS

Pounds Seed per Acre		Seed	Fertilizer (Lbs./A)			Fert.	Plants per	Mult. Range
Alf.	Orch.	Pos.	N	P_2O_5	K_2O	Pos.	sq. ft.	Groups
							Alf. Oct. 7-8, 1957	
20	10	BC	30	0	120	BC	33.2[a/]	
20	10	BC	15	0	120	BC	31.8	
20	10	B	15	0	60	1"b,1"s	30.4	
20	10	B	15	0	60	2"b	30.1	
20	10	B	15	0	120	1"b,1"s	29.3	
20	10	B	15	0	60	1"b,2"s	29.0	
20	10	B	15	0	120	BC	27.1	
20	10	B	15	0	120	1"b,2"s	26.3	
20	10	B	15	0	120	1"b,1"s	26.3	
20	10	B	30	0	120	1"b,1"s	24.4	
20	10	B	30	0	120	1"b,2"s	24.1	
20	10	B	30	0	120	BC	23.2	
20	10	B	30	0	120	2"b	21.4	
10	5	B	15	0	60	1"b,2"s	20.8	
20	10	B	15	0	120	2"b	20.1	
10	5	B	30	0	120	BC	18.5	
20	10	B	15	60	60	1"b,2"s	14.4	
10	5	B	15	0	120	1"b,2"s	14.1	
20	10	B	15	60	60	BC	13.7	

[a/] Each stand count reported represents the mean of 24 (6" x 18" quadrat) counts, 8 quadrats per plot on each of 3 replications.

Pounds Seed per Acre		Seed	Fertilizer (Lbs/A)			Fert.	Plants per	Mult. Range
Alf.	Orch.	Pos.	N	P_2O_5	K_2O	Pos.	sq.ft.	Groups
							Orch. Oct. 7-8, 1957	
20	10	BC	15	0	120	BC	18.5	
20	10	B	30	0	120	1"b,1"s	15.6	
20	10	B	30	0	120	BC	15.4	
20	10	B	15	0	120	BC	14.6	
20	10	B	15	0	120	1"b,1"s	14.2	
20	10	B	15	0	120	1"b,2"s	13.9	
20	10	BC	30	0	120	BC	13.4	
20	10	B	30	0	120	2"b	11.7	
20	10	B	15	0	120	1"b,1"s	11.7	
20	10	B	15	0	120	2"b	11.5	
20	10	B	30	0	120	1"b,2"s	11.3	
20	10	B	15	0	60	2"b	11.3	
20	10	B	15	0	60	1"b,2"s	11.3	
20	10	B	15	0	60	1"b,1"s	11.2	
10	5	B	30	0	120	BC	10.2	
10	5	B	15	0	60	1"b,2"s	9.0	
10	5	B	15	0	120	1"b,2"s	8.1	
20	10	B	15	60	60	BC	7.6	
20	10	B	15	60	60	1"b,2"s	6.4	

ANALYSES OF VARIANCE

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Alfalfa 7-8 October, 1957		
Total	455		
Replications	2	36.00	.88
Treatments	18	390.00	9.48**
Reps. x Tmts.	36	41.14	1.87**
Quadrats	399	21.98	
	Orchardgrass 7-8 October, 1957		
Total	455		
Replications	2	108.00	3.90*
Treatments	18	97.33	3.52**
Reps. x Tmts.	36	27.67	1.87**
Quadrats	399	14.79	

APPENDIX I

EXPERIMENT 6. OCTOBER, 1957 STAND COUNTS OF LADINO AND ORCHARDGRASS FOLLOWING SEEDING ON AUGUST 21, 1957 IN MAURY COUNTY WITH VARYING FERTILIZER AND SEED RATES AND PLACEMENTS

MULTIPLE RANGE GROUPS

Pounds Seed per Acre		Seed	Fertilizer (Lbs/A)			Fert.	Plants per	Mult. Range
Lad.	Orch.	Pos.	N	P_2O_5	K_2O	Pos.	sq.ft.	Groups
							Lad. Oct. 8-9, 1957	
2	14	BC	15	0	60	BC	14.8[a/]	
2	14	BC	15	0	120	BC	13.2	
2	14	B	15	60	60	BC	13.2	
2	14	B	15	0	60	1"b,1"s	12.8	
2	14	B	15	0	60	1"b,2"s	12.6	
2	14	B	15	0	120	BC	12.4	
2	14	B	15	60	60	1"b,2"s	11.4	
2	14	B	15	0	60	BC	10.9	
2	14	B	15	0	120	2"b	10.8	
2	14	B	15	0	120	1"b,2"s	10.4	
2	14	B	15	0	60	2"b	9.9	
2	14	B	15	0	120	1"b,1"s	9.3	
1	7	B	15	0	120	BC	6.1	
1	7	B	15	0	120	1"b,2"s	5.8	
1	7	B	15	0	60	1"b,2"s	5.6	
							Orch. Oct. 8-9, 1957	
2	14	BC	15	0	60	BC	26.0	
2	14	B	15	0	120	1"b,1"s	24.6	
2	14	B	15	0	120	BC	24.4	
2	14	B	15	0	60	1"b,1"s	24.2	
2	14	BC	15	0	120	BC	24.0	
2	14	B	15	0	60	BC	23.2	
2	14	B	15	60	60	1"b,2"s	23.2	
2	14	B	15	0	60	1"b,2"s	23.1	
2	14	B	15	60	60	BC	23.0	
2	14	B	15	0	120	1"b,2"s	20.6	
2	14	B	15	0	120	2"b	20.1	
2	14	B	15	0	60	2"b	18.2	
1	7	B	15	0	120	BC	12.1	
1	7	B	15	0	120	1"b,2"s	12.1	
1	7	B	15	0	60	1"b,2"s	11.7	

[a/] Each stand count reported represents the mean of 24 (6" x 18" quadrat) counts, 8 quadrats per plot on each of 3 replications.

ANALYSES OF VARIANCE

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Ladino 8-9 October, 1957		
Total	359		
Replications	2	185.50	18.79**
Treatments	14	87.50	8.86**
Reps. x Tmts.	28	13.68	1.43
Quadrats	315	9.54	
Pooled error	343	9.87	
	Orchardgrass 8-9 October, 1957		
Total	359		
Replications	2	321.00	7.69**
Treatments	14	259.71	6.22**
Reps. x Tmts.	28	61.64	1.54
Quadrats	315	39.97	
Pooled error	343	41.74	

APPENDIX J

EXPERIMENT 7. OCTOBER, 1957 STAND COUNTS OF LADINO CLOVER AND FESCUE FOLLOWING SEEDING ON AUGUST 22, 1957 IN ROBERTSON COUNTY WITH VARYING FERTILIZER RATES AND FERTILIZER AND SEED POSITIONS

MULTIPLE RANGE GROUPS

Pounds Seed per Acre		Seed	Fertilizer		Plants per	Mult. Range
Lad.	Fesc.	Pos.	Rate	Pos.	sq. ft.	Groups
					Lad. 10 Oct., 1957	
2	14	B	Hi	1"b,1"s	10.6[a]	
2	14	B	Hi	BC	10.1	
2	14	BC	Hi	BC	8.4	
2	14	B	Lo	2"b	7.2	
2	14	B	Hi	2"b	6.4	
2	14	B	Lo	1"b,1"s	6.0	
					Fesc. 10 Oct., 1957	
2	14	B	Hi	2"b	31.5	
2	14	B	Lo	2"b	28.6	
2	14	B	Hi	1"b,1"s	28.0	
2	14	B	Hi	BC	27.8	
2	14	B	Lo	1"b,1"s	26.7	
2	14	BC	Hi	BC	14.6	

[a] Each stand count reported represents the mean of 32 (6" x 18" quadrat) counts, 8 quadrats per plot on each of 4 replications.

ANALYSES OF VARIANCE

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Ladino 10 October, 1957		
Total	191		
Replications	3	17.67	.91
Treatments	5	51.40	2.66
Reps. x Tmts.	15	19.33	1.91*
Quadrats	168	10.10	
	Fescue 10 October, 1957		
Total	191		
Replications	3	152.67	3.03*
Treatments	5	495.80	9.83**
Reps. x Tmts.	15	75.93	1.58
Quadrats	168	48.03	
Pooled error	183	50.32	

APPENDIX K

EXPERIMENT 8. OCTOBER, 1957 STAND COUNTS OF ALSIKE PLUS RED CLOVER AND FESCUE FOLLOWING SEEDING ON AUGUST 22, 1957 WITH VARYING FERTILIZER RATES AND FERTILIZER AND SEED POSITIONS

MULTIPLE RANGE GROUPS

Pounds Seed per Acre			Seed	Fertilizer		Plants per	Mult. Range
Alsike	Red	Fesc.	Pos.	Rate	Pos.	sq. ft.	Groups
						Clover 10 Oct., 1957	
4	6	7	B	Hi	1"b,1"s	17.4[a/]	I
4	6	7	BC	Hi	BC	17.3	I
4	6	7	B	Hi	BC	17.0	I
4	6	7	B	Lo	1"b,1"s	16.0	I
4	6	7	B	Hi	2"b	12.6	
4	6	7	B	Lo	2"b	10.6	I
						Fescue 10 Oct., 1957	
4	6	7	B	Hi	2"b	18.5	I
4	6	7	B	Hi	1"b,1"s	17.1	
4	6	7	B	Hi	BC	14.6	I
4	6	7	B	Lo	2"b	14.4	I
4	6	7	B	Lo	1"b,1"s	13.9	I
4	6	7	BC	Hi	BC	13.2	I

[a/] Each stand count reported represents the mean of 32 (6" x 18" quadrat) counts, 8 quadrats per plot on each of 4 replications.

ANALYSES OF VARIANCE

Source of Variation	Degrees of Freedom	Estimates of Var.	"F" Value
	Clover 10 October, 1957		
Total	191		
Replications	3	66.33	2.12
Treatments	5	116.60	3.72**
Reps. x Tmts.	15	36.80	1.19
Quadrats	168	30.88	
Pooled error	183	31.36	
	Fescue 10 October, 1957		
Total	191		
Replications	3	4.00	.25
Treatments	5	59.20	3.69**
Reps. x Tmts.	15	11.80	.72
Quadrats	168	16.42	
Pooled error	183	16.04	