THE INFLUENCE OF SEEDING RATES ON GRASS SEEDS MIXTURES UNDER DIFFERENT CUTTING TREATMENTS

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Thomas C. Graham

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By

THOMAS C. GRAHAM

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Department of Farm Crops

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Approved C. M. Harrison

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The balance of species in a pasture is determined mainly by the proportion of each species in the seeds mixture and by the rate of seeding. The cutting and grazing management and the application of fertilizers also play an important part. Because of a lack of concrete information on the competitiveness of various species in a complex mixture, a greenhouse experiment was set up to study their behaviour under the contrasting conditions of seeding rates and cutting treatments. Soil fertility remained constant for all cultures.

Rates of seeding were varied from 5 to 40 pounds per acre in two complex grass seeds mixtures, one of which was predominantly ryegrass and in the other cocksfoot was dominant. Half of the cultures were cut at two week intervals, and the other half harvested at the hay stage.

The yield of the ryegrass mixture was not affected by seed rate, and in the final cut, the five pound rate of seeding was equal to the 40 pound rate. In the cocksfoot mixture, the yields increased slightly with seed rate increments. The heavy seed rates gave ryegrass complete dominance in both mixtures, while cocksfoot and timothy developed better under low rates of seeding. At the 40 pound rate, both mixtures

were very similar in botanical composition. Plants in the low seed rate were roughly three times the size of those in the highest seed rate.

The total yield in both mixtures from the hay cutting treatment was double the total yield from five cuttings. Frequent cutting caused considerable injury to the root system of the complex mixtures, whereas the roots of the single species were not affected over the duration of this experiment.

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THE INFLUENCE OF SEEDING RATES ON GRASS SEEDS MIXTURES UNDER DIFFERENT CUTTING TREATMENTS

1. INTRODUCTION

"'Twas expected that the thickness of the plants should help to kill the weeds; yet upon due observation 'tis found that when their excessive numbers have brought a famine amongst them, they are forced to prey one upon the other and 'tho the stronger survive, yet even those are weakened by hunger, that they become the less able to contend with the weeds. This I am certain of, that the least competent number of plants will bring the greatest crop."

These are the words of Jethro Tull, a noted English farmer, who wrote a series of essays on tillage and vegetation in 1733. He had remarkable powers of observation and strongly criticised the traditional husbandry of his day, supporting his theories by a number of simple but very effective experiments. His observations above referred to the seeding of alfalfa, and he proved his point by producing record yields of hay from as low as two pounds of seed per acre.

Tradition rather than knowledge continues to dominate many of our agricultural practices, and this has been particularly evident in the use of grass seeds mixtures. The traditional rate of sowing in most parts of Britain, indeed in most European countries, has been until recently thirty or more pounds of seed per acre. This has usually been justified by the argument that a generous seeding is required for better

weed control and to compensate for adverse soil conditions. Moreover, the use of complex mixtures involving a large number of different species, tended to encourage heavy seed rates, while the farmer himself has always been rather guilty of sowing that little extra seed, "just to be on the safe side."

With better quality seed and improved techniques in sowing and cultivation, the farmer is now using much lower seed rates. This trend has been influenced by the increased use of simpler mixtures, which the plant breeder has made possible by providing a much greater variety of grasses and legumes to suit a wide range of farming conditions. Now, instead of mixing different species together, various strains of one grass and legume are blended together and sown at low rates. Competition between species is reduced to a minimum and grazing management is greatly simplified.

There has always been considerable interest in seed-rate experiments with particular emphasis on simple mixtures, but little attention has been given to the effect of seed-rate on the more complex multi-purpose mixtures which are still in general use. When a large number of species are grown together in a mixture, strong competition in the early stages is inevitable and as the density of plants increases, such competition is greatly intensified.

The balance of species in a mixture is influenced mainly by the rate of seeding and proportion of each species; the soil conditions and fertilizers applied; and finally, the

cutting or grazing management. Because of a lack of concrete information on the competitiveness of various species in mixtures, a greenhouse experiment was set up to study the behaviour of the various components of complex mixtures under the contrasting conditions of seed rates and cutting treatments. Soil fertility remained constant for all cultures.

2. REVIEW OF LITERATURE

There is a wealth of literature on grass seed mixtures, dating back to the late 19th century, when complex mixtures were first used by Robert Elliot, a farmer in the Southern Uplands of Scotland. The subject has been a most controversial one ever since, and even today, there is still some divergence of opinion, both in Britain and the United States, on the relative merit of simple and complex mixtures, and how much seed should be used under various conditions.

The trend towards simple mixtures began in the present century, when Gilchrist, of Cockle Park, and Findlay, of Aberdeen, introduced relatively simple prescriptions with special emphasis on the use of adapted strains of grass and clover. Stapledon and Davies followed with some excellent work at Aberystwyth, Wales by simplifying mixtures even further and blending different grass strains to give more level production throughout the season.

Since the last war, advances in grassland research have been so rapid that most of the reference material quoted comes primarily from that period. The review can be divided into three sections, - seeds mixtures, rate of seeding, and cutting treatments.

Seeds Mixtures. The physiological factors involved in compounding seeds mixtures have been thoroughly examined by Blaser, et al (3), particularly those affecting seedling competition. All the common grasses and legumes have been classified according to their aggressiveness by weighing the

seedlings of each species. Ryegrass was considered very aggressive, orchard grass aggressive, and timothy non-aggressive, while among the clovers, red clover was much more aggressive than white clover.

Competition between the species was influenced greatly by the time of seeding and the addition of nitrogen. As seeding in the spring favored the dominance of grass over legumes, they recommended that the ratio of grass and legumes should be adjusted for spring and summer seedings. In compounding mixtures, they suggest that several simple mixtures of different maturity should be used and manipulated during the season according to growth, rather than a general purpose mixture which will not give such a uniform distribution of grazing.

Simple and complex mixtures were compared by Henson and Hein (9), at Beltsville, over a period of four years. They found that complex mixtures gave superior yields only in the spring of the first year, losing this advantage in July and August. After four years in pasture, Kentucky bluegrass comprised over 90 percent of the grass population of all the mixtures in which it was included.

Hughes (11) obtained similar results in England when he compared the yields and livestock output of simple and complex mixtures. Over a period of three years, the total production of the simple and complex mixtures was very similar, but the simple mixtures gave more uniform production over drought periods. Liveweight gains per acre, however, did not produce

any significant difference over the whole period, but the grazing management of the simple mixtures was much easier.

Aberg, et al, (1) conducted both field and greenhouse studies at Iowa, on grass and legume associations, and found that the results were sometimes reversed on account of wide differences in environmental conditions. In the greenhouse, the yields of forage and roots from orchard grass and timothy were higher in association with alfalfa and brome grass than when grown alone. Timothy and orchard grass, however, were antagonistic as orchard grass reduced the timothy yield when they were grown together.

Rate of Seeding. Heddle and Herriott (8), working under Scottish conditions, compared simple mixtures of ryegrass and cocksfoot at rates of 10, 20 and 30 pounds per acre, with a common seeding of 3 pounds per acre of S 100 white clover. In the first year, ryegrass gave much better ground cover than cocksfoot at the low seed rate, thus preventing the ingress of weeds. In the early stages, more seed gave higher yields, but after the first harvest, the three seed rates gradually equalized. In order to insure quick ground cover, the 20 pound rate was recommended, the 10 pound rate being quite adequate under favorable conditions.

A greenhouse experiment by Erdmann and Harrison (5), studied the effect of ryegrass and redtop used as nurse grasses in lawn and turf mixtures containing Kentucky bluegrass and red fescue at seed rates of 10 to 40 pounds per acre. Ryegrass produced the highest yields and was just as aggressive at the

low seed rates as at the high seed rate. In areas where fast growing nurse grasses are not essential for quick ground cover, they recommend a pure seeding of one turf grass. This view is supported by Juska (14) who found that ryegrass and redtop did more harm than good, due to their aggressive competition in newly established lawn mixtures.

A comprehensive field study by Hunt (13), of 27 grass strains used in Scottish seeds mixtures gave wide variations in percentage establishment. The average for ryegrass was 30 percent, while cocksfoot was 20 percent, and timothy 15 percent. The seed was broadcast at normal rates under a nurse crop of oats on good land. This poor rate of establishment accounts for the farmer's reluctance to risk a low rate seeding unless he is able to drill it.

Parry (16) at Aberystwyth, also found that ryegrass yielded equally well at rates of 24 down to 6 pounds per acre, although the low seeding rate encouraged more weeds in the first year. To counteract this, the proportion of white clover was increased from 1 to 4 pounds, as the amount of ryegrass was decreased. He suggested that the 15 pound rate was quite adequate for a simple mixture, and this could be reduced to 10 pounds when drilled.

MacDonald (15) at Cornell, working with timothy as a pure species found that the yield of hay actually began to decline beyond a seeding rate of 4 pounds per acre. He recommended that seed rates of aggressive species should be reduced to a minimum to give slower grasses a chance to establish. Buller (4)

also obtained similar results at Pennsylvania State University, where seed yields of orchard grass and timothy were slightly reduced by broadcasting double the amount of seed. There was no significant difference, however, with drilling at low and high seed rates. The broadcast seed rates were 3 and 6 pounds per acre, both for orchard grass and timothy. This rate was halved for drilling.

Cutting Treatments. Under greenhouse conditions, Harrison and Hodgson (7), showed that the total yields of grasses cut weekly for eight weeks was less than the final yield from one cutting at the end of the experiment. This applies both to top and root growth and the injury was more severe when the clippings were reduced from 3" to 1" in height. Orchard grass gave nearly double the yield of timothy under the 3" cutting treatment, but they were both almost killed out by the 1" cutting.

Wagner (18), conducted a similar experiment with grass and legumes at Beltsville, varying the interval between clipping and keeping the height of cutting constant at 2". The greatest reduction in growth occurred when the grass was clipped during the later stages of development, and brome grass was more sensitive in this respect than orchard grass. The data suggests that moderate clipping in the early stages should help the legumes and less aggressive grasses to compete against weeds and give quicker establishment.

Under intensive production for grass-drying in Scotland, Holmes and Maclusky (10), observed that heavy nitrogen and

frequent cutting quickly eliminated clover in the mixture, but did not reduce the yield of grass. Grass however, can be gradually killed out by frequent defoliation and applications of nitrogen, as demonstrated by Harrison (6), when he grew Kentucky bluegrass under high temperatures in the greenhouse. The rapid growth exhausts root reserves, and with no leaves to replenish the supply, the plant eventually dies out.

Root growth of grasses grown in mixtures also seems to be affected by interaction between species. This has been confirmed by Ahlgren and Aamodt (2) in the greenhouse, using bluegrass, timothy and redtop. They found that the weight of roots per plant was greater when grown in pure culture than in mixtures, indicating some antagonism between the species.

A field experiment carried out in England by Hughes and Davis (12), correlated fairly closely with the results obtained in this experiment. A ryegrass mixture and a cocksfoot mixture seeded at 6 and 18 pounds per acre were compared under grazing and cutting treatments for a period of three years. The low seed rate gave just as good results as the high seed rate, while yields from the hay and aftermath treatment in the first year almost doubled that from rotational grazing. The plots were grazed by sheep and rested for two week intervals.

Half the plots received nitrogen, and in the third year pasture, those plots only contained about 5 percent white clover, while the plots without nitrogen had almost 20 percent. There was even further reduction of white clover by the hay treatment along with nitrogen. The seed rates had no

significant effect on the clover content, but in the absence of nitrogen, it was observed that more clover had colonized the cocksfoot plots at the low rate of seeding.

3. EXPERIMENTAL PROCEDURE

The experiment was started in the greenhouse at Michigan State University, East Lansing, Michigan, in January 1956, and completed at the end of May. The seedings were made in 10" clay pots using quartz sand and a standard nutrient solution. The three principal grasses used in compounding mixtures - ryegrass, cocksfoot and timothy were grown as single species and in two complex mixtures, with the clover standard throughout all the mixtures.

The single species were Domestic ryegrass (Lolium multiflorum), Perennial ryegrass (Lolium perenne), Orchard grass (Dactylis glomerata), two pedigree strains of cocksfoot, S 37 and S 143,* and timothy (Phleum pratense). Two complex mixtures were used - one in which ryegrass predominated, and in the other cocksfoot was predominant. The proportion of timothy and clover was constant in both. Details of the mixtures are as follows: -

Single Grass Mixtures.

1.	18	lbs/ac	Domestic ryegrass
2.	12	"	Commercial Perennial ryegrass
	6	"	S 23 Perennial ryegrass (Pasture type)
3.	14	"	Orchard grass (Danish cocksfoot)
4.	7	"	S 37 cocksfoot (hay type)
	7	"	S 143 cocksfoot (pasture type)
5.	8	"	Timothy

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* Orchard grass is known as Danish cocksfoot in Britain. S 37 and S 143 are British strains of cocksfoot.

Each mixture contained a standard clover seeding as follows: -

1 lb. Red clover

½ lb. New Zealand white clover

¼ lb. S 100 white clover

¼ lb. Kent wild white clover

Complex Mixtures.

The ryegrass - dominant mixture contained 50 percent ryegrass and 25 percent cocksfoot, while in the cocksfoot - dominant mixture the proportions were reversed. For convenience, these mixtures will be referred to as Ryegrass mixture and Cocksfoot mixture.

1. Ryegrass mixture (40 lb. rate)

4 lbs	Domestic ryegrass
6 "	S 23 Per. "
10 "	Commercial "
4 "	Orchard grass
3 "	S 37 cocksfoot
3 "	S 143 "
6 "	Timothy
2 "	Red clover
1 "	N. Z. white clover
½ "	S 100 " "
½ "	Wild " "

2. Cocksfoot mixture (40 lb. rate)

2 lbs	Domestic ryegrass
3 "	S 23 Per. "
5 "	Commercial "
8 "	Orchard grass
6 "	S 37 cocksfoot
6 "	S 143 "
6 "	Timothy
2 "	Red clover
1 "	N. Z. white clover
½ "	S 100 " "
½ "	Wild " "

Four seeding rates, 5, 10, 20 and 40 pounds per acre were used. The 20 lb. per acre rate in the greenhouse was regarded as equivalent to a normal seeding rate in the field and used as a check.

To insure the accuracy of seeding rates, the seeds in each species were counted and the proportions used were as follows: -

Ryegrass	1	lb/ac	equiv.	to	3	seeds	per pot
Orchard	1	"	"	"	6	"	" "
Cocksfoot	1	"	"	"	8	"	" "
Timothy	1	"	"	"	12	"	" "
Red clover	1	"	"	"	4	"	" "
White clover	1	"	"	"	12	"	" "

Germination in all the samples was over 90 percent, and no fungicide was used. The mixtures were sown on the 29th of January, and replicated six times.

The experiment was set up in a split plot design, so that one half could be clipped regularly at two week intervals to represent grazing treatment, while the other half was allowed to go to the hay stage before cutting. An aftermath cutting was taken so that both treatments were completed at the end of May, after four months growth. The greenhouse temperature fluctuated between 65° and 70° F. for the first three months, but was much more irregular in May, when it sometimes reached 90° F.

The cultures were watered as required, and after emergence, received a three salt nutrient solution once a week. The pH remained fairly constant at 7.2, and to prevent excessive accumulation of salts, the pots were flushed out regularly with water. There was considerable variation in the water requirements of each pot, some drying out much more quickly than others, and causing irregular growth. Individual watering

compensated to some extent.

All the seedlings had emerged by two weeks with ryegrass first, followed by orchard, red clover, cocksfoot, white clover and timothy in that order. Seedling counts were made before clipping was started on the 27th of March. The single grass species were further advanced than the mixtures, being about eight inches tall before the first cutting, while the complex mixtures averaged only five inches, but this evened out before the second cutting. The clippings were taken two inches above the sand level.

The species were hand separated at the time of cutting for botanical analysis, and the green weight and oven dry weight recorded. Cultures at the hay stage were harvested on the 15th of May, and the aftermath was cut two weeks later. Chemical analyses were made for a comparison of crude protein. (Table 3.)

After the final harvest, the root systems were examined by selecting an average culture from each treatment. The sand was carefully washed away from the roots and individual plants were counted before green and oven-dry weights were taken. As clover had almost been eliminated from most of the cultures, separate counts were not taken. The few which had survived were very poorly developed.

4. EXPERIMENTAL RESULTS

1. Comparison of Yields of Mixtures.

Yields were compared at a normal rate of seeding equivalent to 20 pounds per acre. Rates for cocksfoot and timothy were reduced to 14 and 8 pounds respectively in the simple mixture, in order to obtain a comparable number of plants in each seeding. Plant counts taken before the first cutting revealed that there was little difference between the various mixtures.

Seedling counts per culture: -

Ryegrass	Cocksfoot	Timothy	Ryegrass mixt.	Cocksfoot mixt.
64	70	75	69	81

Table 1 gives the dry weight yields under the five clipping treatments. Orchard grass made good initial growth, but did not stand up as well as ryegrass to continuous cutting. The ryegrass mixture was slightly superior to the cocksfoot mixture, which did not maintain its yield in the last two cuttings.

The hay and aftermath yields are given in Table 2, and with the exception of ryegrass, were almost double the total yield from 5 cuttings. Perennial ryegrass and orchard grass gave the lowest yields, while domestic ryegrass gave the highest yield of hay. The cocksfoot mixture under this treatment was superior to the ryegrass mixture. An analysis of the percentage clover in the aftermath showed that domestic ryegrass almost eliminated the clover, while timothy and perennial ryegrass gave the best clover counts.

Green weight yields are given in Table 3 and show that

orchard grass was the lowest producer in both cutting treatments, while domestic ryegrass was the highest. There was a considerable variation in the percentage dry matter between the species, with domestic ryegrass lowest, and timothy highest in both cases. When a crude protein analysis was taken at the time of the third clipping and at the hay stage, the cultures which were regularly clipped gave an average protein of 36 percent, which dropped to 24 percent in the hay.

There were only slight differences in analysis between the different mixtures, and considering that there was less than 5 percent clover in the average mixtures, the protein content was very high. When the average protein yield from both cutting treatments were compared, the hay and aftermath cuttings were still superior to the clipping treatment.

Fig. 1, illustrates the difference in growth between the single species and the complex mixtures, and Fig. 2 gives a comparison between the ryegrass and cocksfoot mixtures before cutting commenced. Ryegrass was dominant in both mixtures and crowded out cocksfoot and timothy particularly at the heavy rates of seeding.

TABLE 1

COMPARISON OF YIELDS OF MIXTURES

Dry weight yield in grams

(Average of three cultures)

FIVE CLIPPINGS

MIXTURES	March 27	April 10	April 24	May 8	May 22	TOTAL
Domestic ryegrass	1.8	4.4	12.0	15.4	19.1	52.7
Perennial ryegrass	2.5	3.8	7.6	10.3	13.3	37.5
Orchard grass	2.9	4.5	8.0	7.3	7.4	30.1
Cocksfoot	2.0	4.0	8.3	8.1	8.5	30.9
Timothy	1.6	4.2	8.0	8.8	10.6	33.2
Ryegrass mixture	2.3	4.1	8.9	11.0	11.3	37.6
Cocksfoot mixture	1.7	5.1	8.5	7.6	7.1	30.0

TABLE 2

COMPARISON OF YIELDS OF MIXTURES

Dry weight yield in grams

(Average of three cultures)

CUT TWICE - Hay stage and aftermath

MIXTURES	May 15	May 29	Total yield	Percent clover in aftermath
Domestic ryegrass	65.5	10.5	76.0	0.3
Perennial ryegrass	34.6	14.9	49.5	6.2
Orchard grass	42.0	7.5	49.5	4.1
Cocksfoot	54.0	8.6	62.6	4.4
Timothy	55.1	10.2	65.3	6.6
Ryegrass mixture	57.3	15.1	72.4	2.9
Cocksfoot mixture	61.7	17.1	78.8	4.2

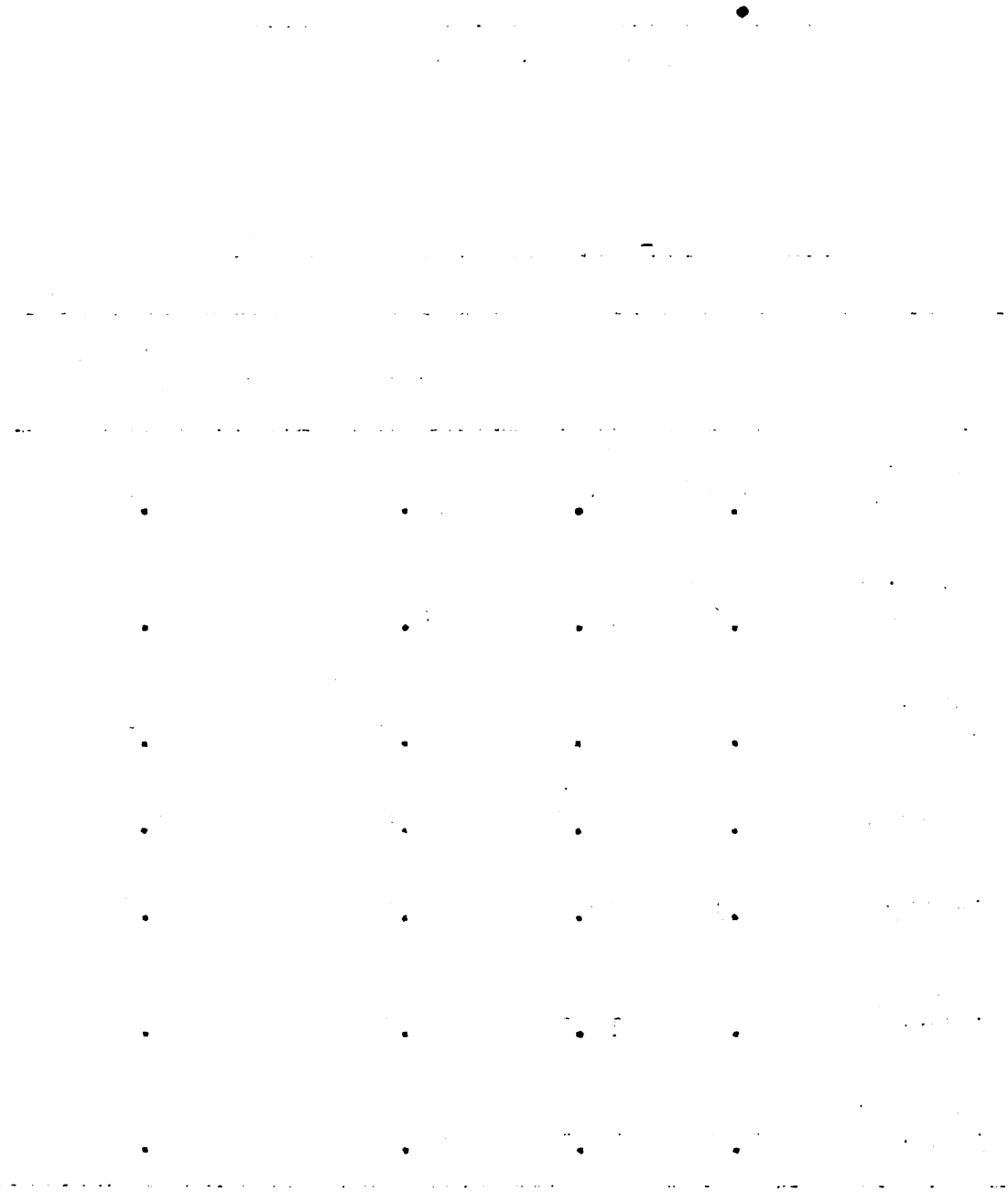
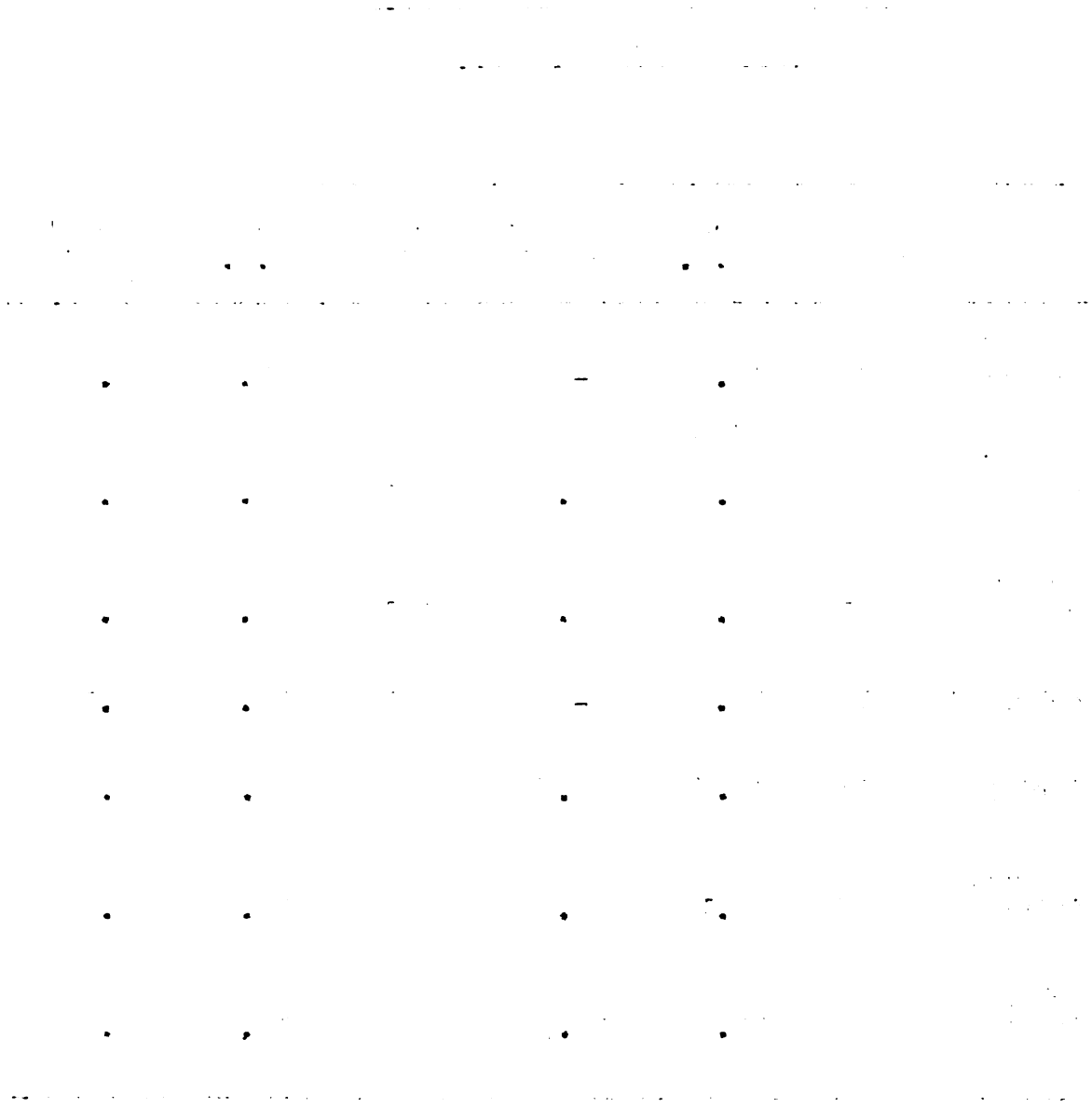


TABLE 3

TOTAL GREEN WEIGHT AND PROTEIN

ANALYSIS OF MIXTURES

MIXTURES	CUT FIVE TIMES			CUT TWICE		
	green weight	percent D.M.	percent protein	green weight	percent D.M.	percent protein
Domestic ryegrass	415	12.7	-	644	11.8	23.0
Perennial ryegrass	282	13.3	35.8	383	12.9	29.0
Orchard grass	201	15.0	35.0	361	13.8	22.6
Cocksfoot	213	14.5	-	481	13.0	23.1
Timothy	214	15.5	33.5	438	14.9	22.2
Ryegrass mixture	287	13.1	37.7	517	14.0	25.5
Cocksfoot mixture	222	13.5	36.7	532	14.8	24.2



Domestic ryegrass | Perennial ryegrass | Orchard grass | Cocksfoot | Timothy

Fig. 1. Mixtures ready for the first cutting.

Above - Single grass mixtures.

Below - Complex mixtures at 4 rates of seeding.

5 lbs. - 10 lbs. - 20 lbs. - 40 lbs. per acre.

Fig. 2. Comparison of complex mixtures before the first cutting under different rates of seeding.
Above - Ryegrass mixture. Below - Cocksfoot mixture.
Rates of seeding - 5 - 10 - 20 - 40 pounds per acre.

2. EFFECT OF SEEDING RATE ON YIELD OF MIXTURES

Table 4 gives the dry weight yields of the two complex mixtures under two cutting treatments. On account of their different behaviour, each mixture will be considered individually.

Ryegrass mixture. For the first two cuttings, the yields increased as the seed rate increased, so that there was about twice the yield from the 40 when compared with the 5 pound rate. By the third cutting, yields began to equalize until in the final cutting, the 40 pound rate actually gave a lower yield than the 5 pound rate. Over the whole period, there was little difference in total yield, although the 20 pound rate had a slight advantage over the others. Differences in total yield in the hay treatment were not significant, but still showed the same general trend as the seed rate increased. The Coefficient of Variance was below 5 percent in both cases.

Cocksfoot mixture. For the first three cuttings, this mixture responded in very much the same way as the ryegrass mixture, except that the 40 pound rate gave a slightly higher yield. The yields began to diminish for the next cutting and this continued in the final cutting, showing that cocksfoot did not withstand severe clipping as well as ryegrass. Over the whole period, there was a wider gap in total yield between each seed rate. Analysis of the data shows that the difference in yields was significant for the clipping treatment, but in the hay treatment, only the 40 pound rate gave a significant increase over the 5 and 10 pound rates.

TABLE 4

EFFECT OF SEEDING RATE ON YIELD OF COMPLEX MIXTURES

Dry weight in grams. (Average of three cultures)

RYEGRASS MIXTURE (Five clippings)

Seed rate per acre	March 28	April 11	April 25	May 9	May 23	TOTAL
5 lbs.	0.9	2.5	8.2	10.3	10.4	32.3
10 "	1.2	2.9	8.5	10.7	10.5	33.8
20 "	2.3	4.0	8.9	11.0	11.3	37.6
40 "	2.2	4.7	9.2	10.6	9.5	36.2

L.S.D. (5%) = 2.2 gms.

COCKSFOOT MIXTURE (Five clippings)

Seed rate per acre	March 28	April 11	April 25	May 9	May 23	TOTAL
5 lbs.	1.3	3.5	7.7	6.9	5.1	24.5
10 "	1.3	4.2	8.4	7.3	6.5	27.7
20 "	1.7	5.1	8.5	7.6	7.1	30.0
40 "	2.1	6.1	11.3	10.0	8.4	37.9

L.S.D. (5%) = 2.4 gms.

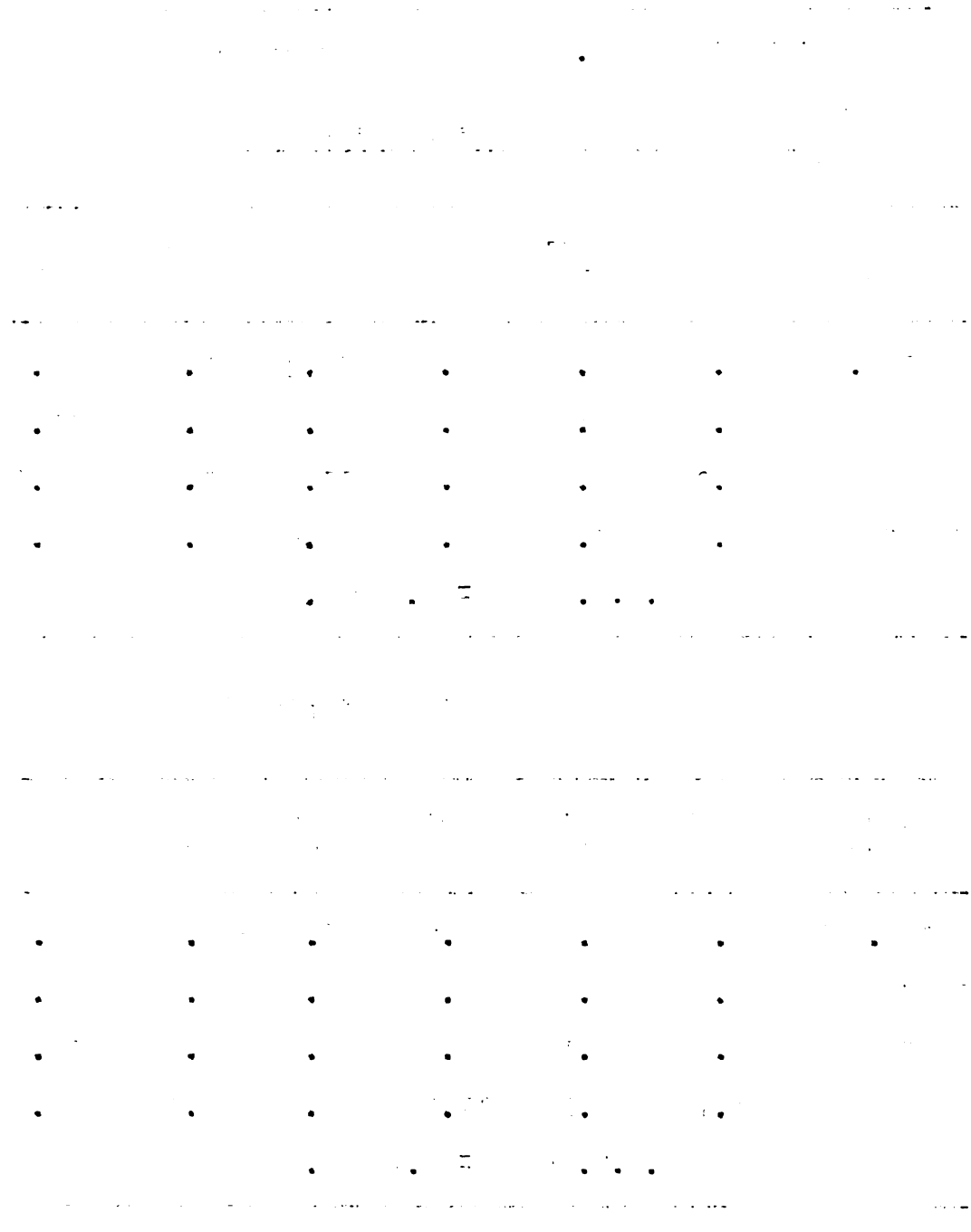


TABLE 4 (cont.)

EFFECT OF SEEDING RATE ON YIELD OF COMPLEX MIXTURES

Dry weight in grams. (Average of three cultures)

TWO CUTTINGS, HAY STAGE AND AFTERMATH.

Seed rate	Ryegrass mixture			Cocksfoot mixture		
	May 16	May 30	Total	May 17	May 31	Total
5 lbs.	56.0	15.2	71.1	49.7	12.8	62.5
10 "	56.6	15.4	72.0	51.1	12.9	64.0
20 "	57.3	15.1	72.4	61.7	17.1	78.8
40 "	58.9	14.9	73.8	73.7	19.9	93.6
	L.S.D. (5%) - 6.6 gms.			L.S.D. (5%) - 16 gms.		

Fig. 3 shows the growth patterns of the two mixtures under the clipping treatment. The mixtures were fairly similar in growth up to the third cutting when the cocksfoot mixture began to decline. Fig. 4 brings out the striking difference between the two cutting treatments, the total yields from the hay and aftermath being about double the yield from five cuttings.

Fig. 5 shows pictures of the single grass species under the two cutting treatments. Figs. 6 and 7 give comparisons between the two complex mixtures at the third and fifth cuttings. Growth tended to be coarser and more straggling at the low seed rates while the 40 pound rate produced a finer more erect growth.

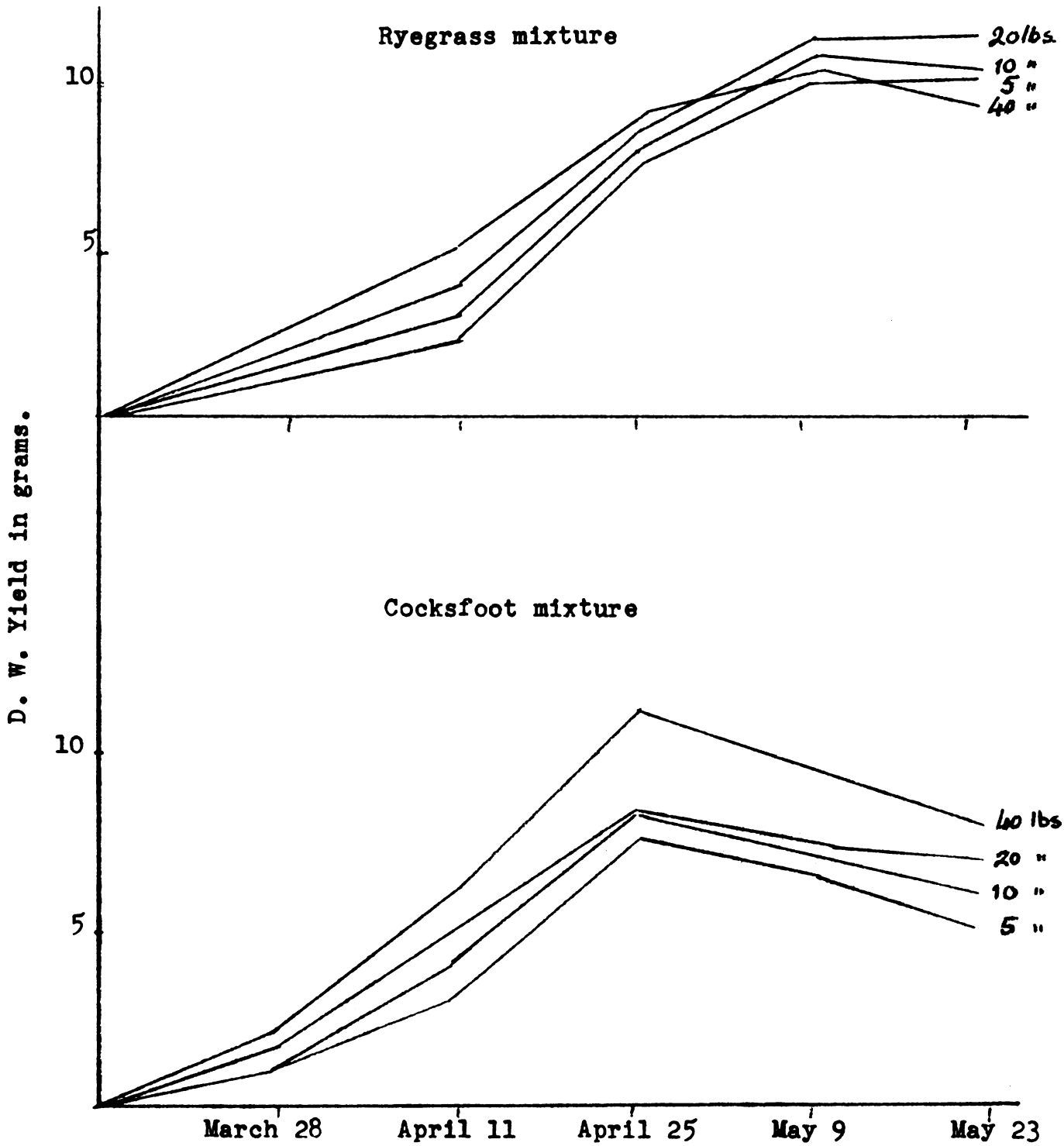


Fig. 3. The effect of seeding rate on the growth pattern of complex mixtures, cut five times.

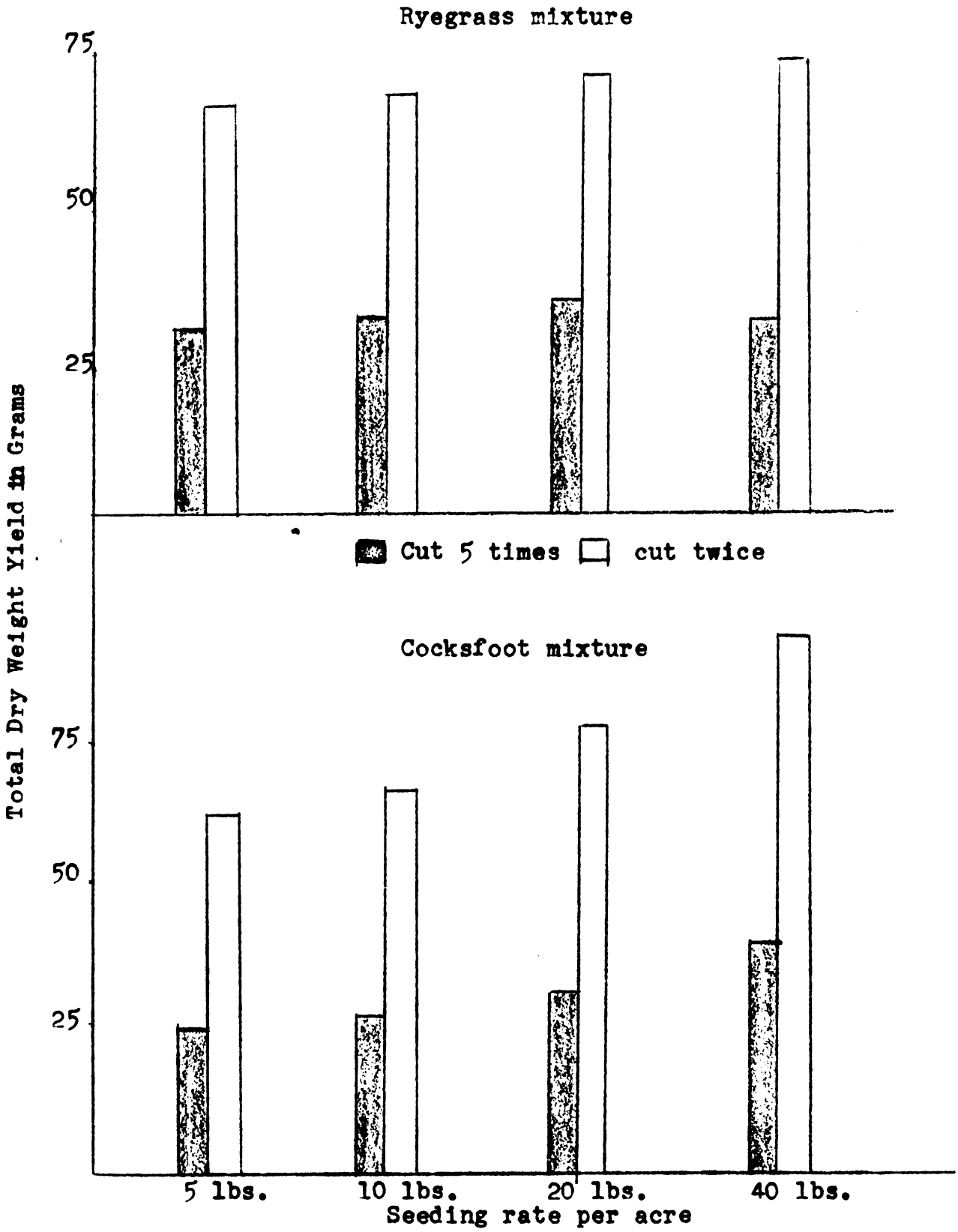


Fig. 4. The effect of seeding rate and cutting treatment on the yields of complex mixtures.

Domestic ryegrass | Perennial ryegrass | Orchard grass | Cocksfoot | Timothy

Perennial ryegrass | Domestic ryegrass | Orchard grass | Cocksfoot | Timothy

Fig. 5. Single grass mixtures at normal seeding rate.

Above - before the fifth clipping.

Below - before cutting at the hay stage.

Fig. 6. Comparison of complex mixtures before the third cutting at different rates of seeding.
Above - Ryegrass mixture. Below - Cocksfoot mixture.
Rates of seeding - 5 - 10 - 20 - 40 pounds per acre.

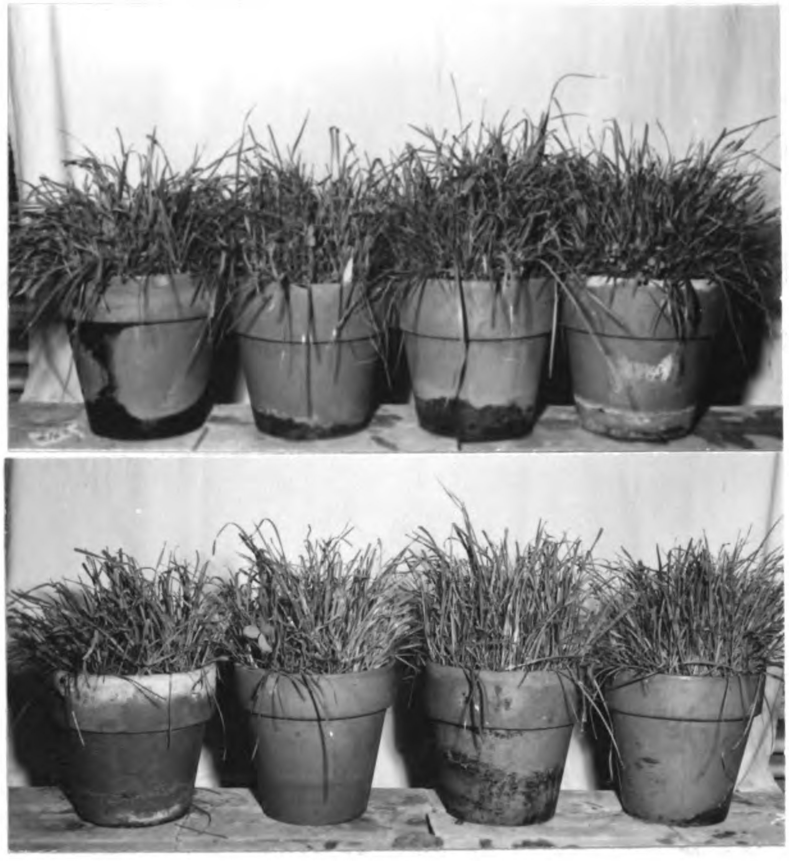


Fig. 7. Comparison of complex mixtures before the fifth cutting at different rates of seeding.
Above - Ryegrass mixture. Below - Cocksfoot mixture.
Rates of seeding - 5 - 10 - 20 - 40 pounds per acre.

3. EFFECT OF SEED RATE AND CUTTING TREATMENT ON BOTANICAL ANALYSIS OF MIXTURES

The percentage analysis by weight of each species in the mixture has been averaged in Table 5. To find the effect of rate of seeding on the composition of the mixtures, only the data for the extreme rates of seeding have been used. In all cases, the 10 and 20 pound rates were intermediate in effect.

Where the cultures were clipped frequently, the proportion of ryegrass in both mixtures increased slightly in the high seed rate at the expense of cocksfoot. The changes in botanical composition, however, were much more marked in the hay cutting treatment. Ryegrass maintained complete dominance in both mixtures at the high seed rates at the expense of both cocksfoot and timothy, but at the low seed rate, cocksfoot was dominant. Clover was not affected by seeding rate under either cutting treatment.

Fig. 8 shows the ryegrass/cocksfoot ratio in the fifth cutting and the aftermath of both mixtures. This presents a more realistic picture of how the mixtures looked at the end of the experiment. Again, it shows that seed rates exerted only a slight influence on the balance of the mixture after five cuttings, but in the aftermath cutting, there was a distinct bias toward cocksfoot at the low seed rates.

TABLE 5

EFFECT OF SEED RATE AND CUTTING TREATMENTS ON BOTANICAL ANALYSIS OF MIXTURES

Percentage analysis based on average dry weight of all cuttings.

Comparison of mixtures at 5 lb. and 40 lb. rate.

RYEGRASS MIXTURE

Percent Analysis	Ryegrass		Cocksfoot		Timothy		Clover	
	5#	40#	5#	40#	5#	40#	5#	40#
5 cuttings	51	58	30	21	17	18	2	3
2 cuttings	38	59	44	27	15	10	3	4

COCKSFOOT MIXTURE

Percent Analysis	Ryegrass		Cocksfoot		Timothy		Clover	
	5#	40#	5#	40#	5#	40#	5#	40#
5 cuttings	35	43	46	36	16	19	3	2
2 cuttings	25	51	55	34	17	10	3	5

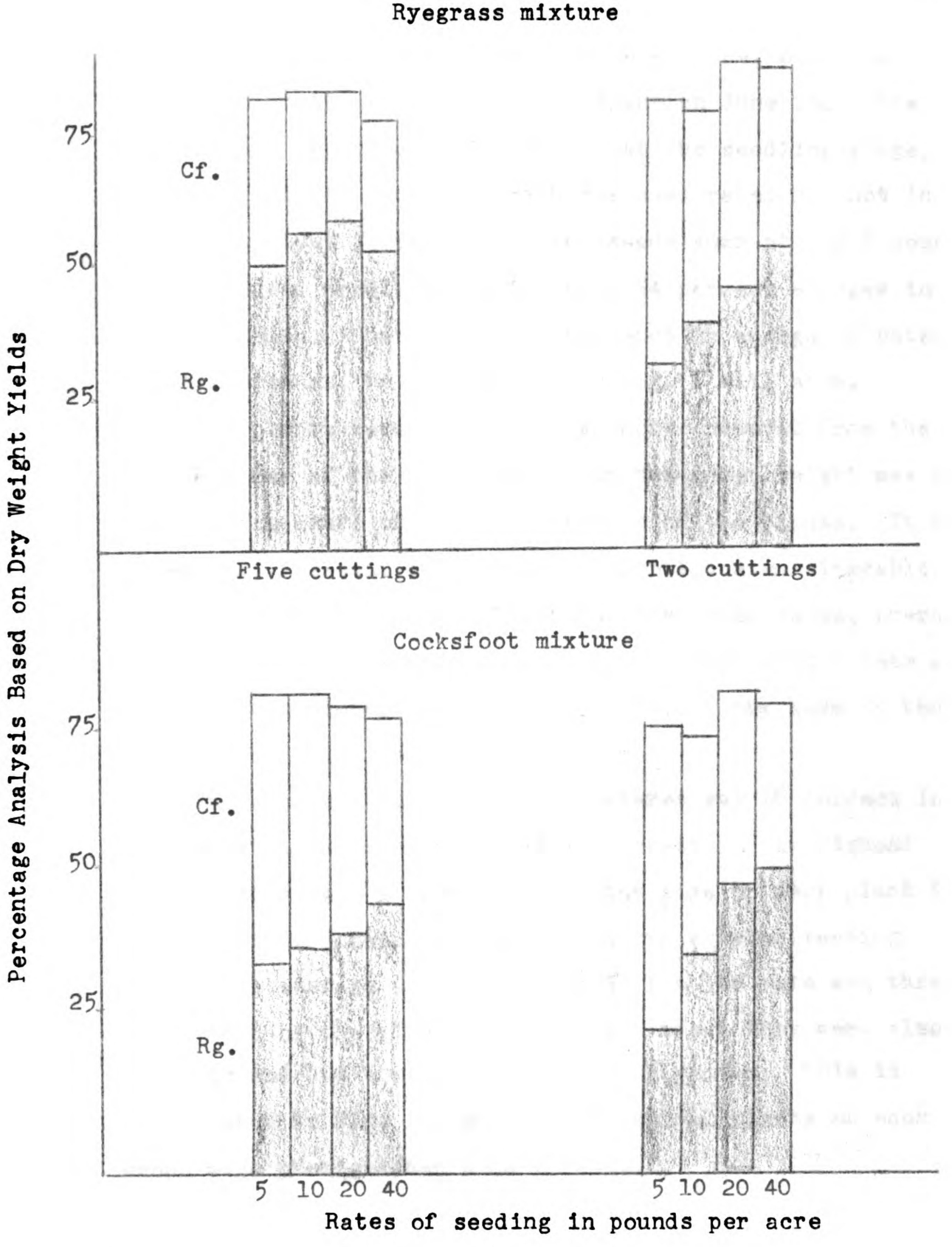


Fig. 8. The effect of seeding rate and cutting treatment on ryegrass - cocksfoot ratio in mixture.

4. EFFECT OF SEED RATE ON ESTABLISHMENT

Plant counts were taken after emergence, on March 10th and again at the end of the experiment on June 2nd. The results are reported in Table 6. At the seedling stage, the number of plants increased with the seed rate, but not in proportion. About 75 percent of the seeds sown at the 5 pound rate produced seedlings, while only 54 percent emerged in the 40 pound rate. There was no difference in emergence between the mixtures as the photographs in Fig. 9 will show.

The plants were again counted after removal from the pots at the close of the experiment, and the green weight was taken to give a measure of the average size of the plants. It was noted that frequent cutting had eliminated a considerable number of plants, especially at the high seed rates, whereas cutting twice was much less severe. In the 5 pound rate of seeding, the number of plants was actually the same as the original seedling count.

The average stand for both mixtures was 68 percent in the lowest rate of seeding and 37 percent in the highest rate of seeding. A comparison in the size of each plant is equally significant. Comparing the two extreme seeding rates, the average size of plants in the low rate was three times that of the plants in the high rate. They were also more vigorous and had a well developed root system. This is illustrated in Fig. 12, where four typical plants of each group were photographed side by side.

TABLE 6

EFFECT OF SEED RATE ON ESTABLISHMENT

Plant counts average of three cultures

SEEDLING STAGE - March 10th

	RYEGRASS MIXTURE				COCKSFOOT MIXTURE			
	5#	10#	20#	40#	5#	10#	20#	40#
No. of seeds sown per pot	30	60	120	240	32	64	128	256
Av. No. of seedlings	22	43	69	128	25	46	81	141
Percentage emergence	73	71	58	53	78	72	63	55

PLANT COUNTS AFTER ROOT SEPARATION - June 2nd

	RYEGRASS MIXTURE				COCKSFOOT MIXTURE			
	5#	10#	20#	40#	5#	10#	20#	40#
Five cuttings	18	30	54	75	18	24	50	82
Two cuttings	25	30	52	105	23	35	58	110
Av. wt. of each plant	1.3	1.0	0.6	0.4	1.3	1.1	0.6	0.4
Final .Cut5x	60	50	45	31	56	38	40	32
percent. stand .Cut2x	83	50	43	44	72	55	45	43

Ryegrass Orchard Cocksfoot Timothy

Fig. 9. Seedling emergence of mixtures.
Above - Single Grass mixtures at normal rate of seeding.
Below - Complex mixture at different rates of seeding.
Rates - 40 lbs. - 20 lbs. - 10 lbs. - 5 lbs. per acre.

5. EFFECT OF SEED RATE AND CUTTING TREATMENT ON ROOT GROWTH

After the final cutting, the root system of each mixture was examined, using one culture from each treatment as an example. The weight of oven-dry roots is given in Table 7.

The results from the single grass mixtures indicate that ryegrass produced the strongest root system, while orchard grass had the weakest. This was in accordance with the production of top growth which demonstrated that orchard grass did not resist continuous defoliation as well as ryegrass. Comparing the two cutting treatments, no difference in root growth was observed, and the roots were not adversely affected by frequent cutting over the duration of the experiment.

In the complex mixtures, frequent cutting distinctly reduced the amount of roots, particularly in the ryegrass mixture. In the heavier seed rates, the roots from the aftermath were almost double those from the fifth cutting, and this correlated very closely with the corresponding forage yields. It appears that the root/top ratio remained constant at both cutting treatments, and as forage yields dropped, the root system diminished.

Seeding rate had the same general effect on root growth as it had on top growth. There was a gradual increase in roots as the rate of seeding went up, and this was more apparent in the hay cutting treatment. Photographs in Figs. 10, 11, and 12 show the effect of seed rate and cutting treatment on root growth.

TABLE 7

EFFECT OF CUTTING TREATMENTS ON ROOT GROWTH

Dry weight in gms. of washed roots in each culture

SINGLE GRASS MIXTURES

Cutting treatment	Domestic ryegrass	Perennial ryegrass	Orchard grass	Cocksfoot	Timothy
5 cuttings	11.8	10.8	8.1	9.5	9.8
2 cuttings	12.2	11.1	8.4	10.0	10.1
Percent diff. between cuttings	3	3	4	5	3

COMPLEX MIXTURES

Cutting treatment	Ryegrass mixture				Cocksfoot mixture			
	5#	10#	20#	40#	5#	10#	20#	40#
5 cuttings	6.1	6.5	7.2	7.8	6.8	7.0	7.1	7.2
2 cuttings	10.5	11.6	14.8	15.1	9.2	10.0	13.1	13.2
Percent diff. between cuttings	72	78	105	94	35	43	85	83

Rates - 5 - 10 - 20 - 40 pounds per acre.

Fig. 10. Complex mixture before and after root separation.

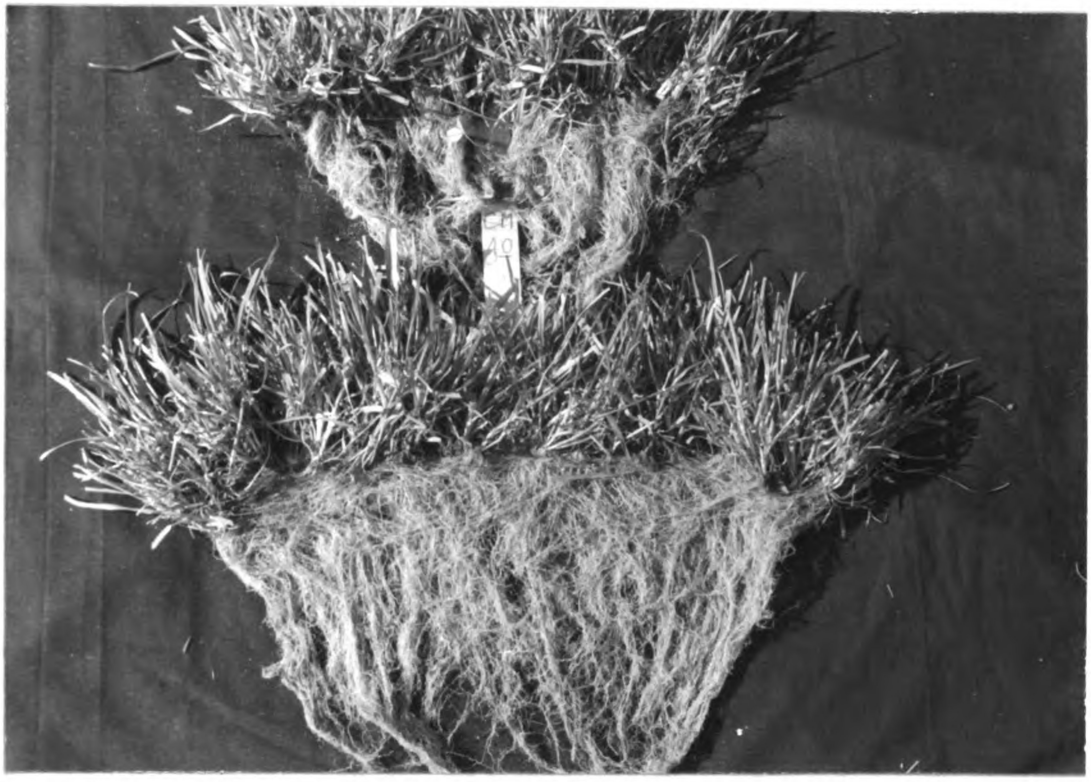
Above - Cultures after final cuttings.

Below - Washed roots of cultures.

Front - After 5 cuttings; Rear - After 2 cuttings.

Fig. 11. Root growth of complex mixture after different rates of seeding and cutting treatments.

5 lb. rate		40 lb. rate	
2 cuttings	5 cuttings	2 cuttings	5 cuttings



Upper culture - 5 lb. rate; Lower culture - 40 lb. rate.

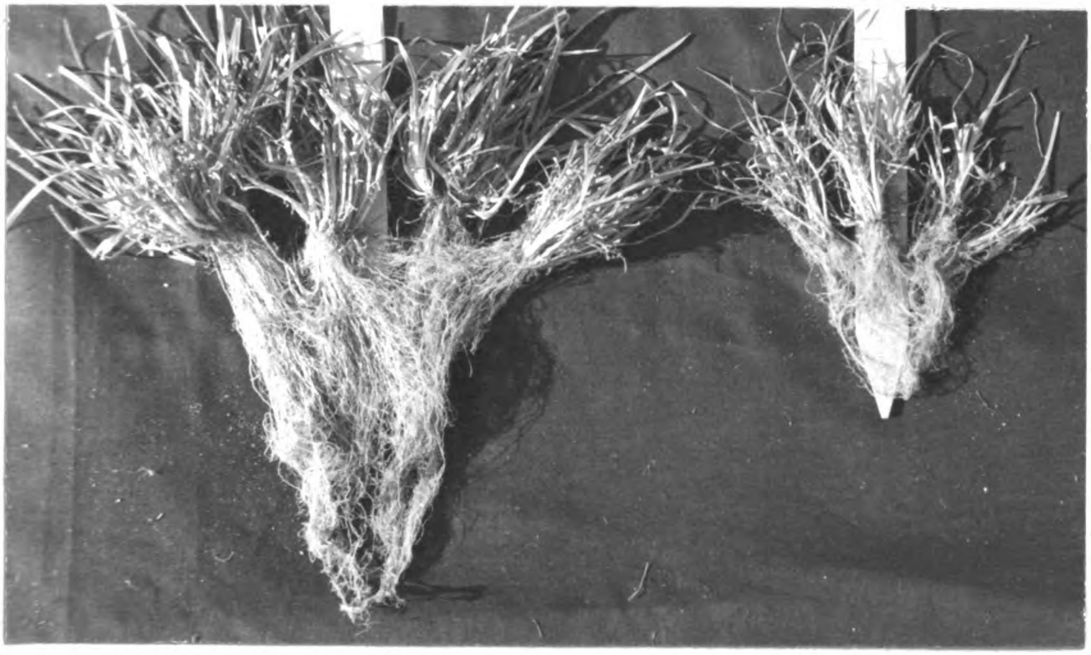


Fig. 12. Root growth of complex mixture at different seed rates.

Above - Cultures from 5 lb. and 40 lb. seed rate.

Below - Comparison of size of four individual plants.

Left - 5 lb. rate Right - 40 lb. rate

5. DISCUSSION

This experiment was conducted under controlled conditions in the greenhouse where there was a plentiful supply of moisture and nutrients, and a favourable temperature for rapid growth of grass. Moreover, the seedings were made under ideal cultural conditions without a nurse crop and with complete freedom from weeds and volunteer grasses. Nevertheless, it can be used to illustrate the basic principles of competition between species in a complex mixture and how this is affected by the rate of seeding and subsequent management. The injurious effect of persistent cutting on the root system of grasses has also been demonstrated very effectively.

The first object of the experiment was to find out how reduced rates of seeding affected the yield and competition between the species in a complex mixture. A wide range of seed rates was used, so that the growth pattern could be observed under extreme conditions. The main competition in a general mixture comes from ryegrass and cocksfoot, and in order to study their behaviour, two complex mixtures were made up with the proportion of each actually reversed. This gave ryegrass initial dominance in one mixture and cocksfoot dominance in the other.

The only way to interpret these results is to compare yields of dry matter between the rates of seeding, and in both cutting treatments, the two mixtures gave remarkably consistent results. The standard ryegrass mixture, whether it was cut twice or five times, gave very similar yields at all rates of

seeding, while in the cocksfoot mixture, the rates equalized at the third cutting, but in the last two cuttings, yields dropped considerably. The 40 pound rate had a distinct advantage in the early stages of growth, but by the third clipping the low rates had tillered out so well, that the yields were almost equal.

This would indicate, therefore, that the traditional rate of seeding for general purpose mixtures is excessive, and could be reduced considerably without affecting its performance. Quite apart from the economy in seed, a moderate seed rate with a small proportion of ryegrass gives a better balanced mixture of species, allowing more room for the less aggressive grasses to develop. A quick growing nurse grass, such as ryegrass, can be of real value in giving rapid ground cover against weeds, but it also competes with the slower growing species in the mixture. There is still a tendency to use too much ryegrass in mixtures mainly because it is cheap and adds bulk to the mixture.

Botanical analysis illustrated this point very well in the cocksfoot mixture at the heavy rate of seeding. In the initial seeding, there was 50 percent cocksfoot and 25 percent ryegrass, but in the final cutting at the high rates of seeding, the situation was reversed as ryegrass occupied 50 percent of the stand, leaving cocksfoot with about 35 percent. In fact, after the hay cutting treatment, both mixtures were almost identical in composition at the 40 pound rate. This shows that ryegrass can exert a strong influence in the mixture even at the moderate proportion of 25 percent.

Summarizing the combined effects of seed rate and cutting treatment, it appears that a high rate of seeding plus frequent cutting, both favour the more aggressive ryegrass, while cocksfoot and timothy have a better chance of survival at low seed rates under a moderate cutting treatment. It was observed that cutting down to 2 inches was more severe on cocksfoot and timothy, which were more erect in growth than ryegrass, and as a result, did not make such quick recovery.

Examination of the root system substantiated the results obtained from the top growth. An increase in seed-rate produced overcrowding, and as a result, the roots of grasses seeded at the 40 pound rate were very small and poorly developed. This was particularly evident in the ryegrass mixture, when the yield in the final cutting dropped considerably partly due to excessive competition for moisture and nutrients.

The effect of the two cutting treatments on root growth was most apparent and definitely proved that too frequent cutting causes considerable injury to the roots, as well as reducing the yields of forage. The yields of top and root growth of the single grass mixtures were not adversely affected by cutting five times, which might indicate that single species can withstand frequent cutting better than complex mixtures. However, the clipping treatment would have to be extended for several more weeks before this could be confirmed.

SUMMARY AND CONCLUSIONS

1. Rates of seeding were varied from 5 to 40 pounds per acre in two complex grass seeds mixtures, half of which was cut at two week intervals, and the other half harvested at the hay stage.
2. Single grass mixtures at a standard rate of seeding were used for checking results. The species used were ryegrass, orchard grass, cocksfoot and timothy, and the proportion of clover in each mixture was constant.
3. The yield of the ryegrass mixture was not affected by seed rate, and in the final cut, the five pound rate of seeding was equal to the 40 pound rate. In the cocksfoot mixture, the yields increased slightly with seed rate increments.
4. The heavy seed rates gave ryegrass complete dominance in both mixtures, while cocksfoot and timothy developed better under low rates of seeding. At the 40 pound rate both mixtures were very similar in botanical composition.
5. Plants in the low seed rate were roughly three times the size of those in the highest seed rate.
6. The total yield in both mixtures from the hay cutting treatment was double the total yield from five cuttings.
7. Frequent cutting caused considerable injury to the root system of the complex mixtures, whereas the roots of the single species were not affected over the duration of this experiment.

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