A STUDY OF VARIOUS MULCHES FOR STAND ESTABLISHMENT OF SMALL-SEEDED LEGUMES

By

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A STUDY OF VARIOUS MULCHES FOR STAND ESTABLISHMENT

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INTRODUCTION

In 1956 "Oklahoma Agriculture" reported that approximately 856,000 acres of Oklahoma soil were devoted to production of small-seeded legumes for hay, pasture, seed production and soil building.

Small-seeded legumes planted in a clean seedbed commonly result in poor stands. Many times it is necessary to replant fields of these legumes because of the poor stands obtained. Many failures in stand establishment can be attributed to poor emergence or seedling injury from wind and soil movement brought about by the soil crust formed by a rain immediately after planting.

The workers in horticultural research have, to a certain extent, mastered this problem of crusting by the use of some new mulching materials and by developing some new techniques with a few of the more common mulches. Several of these workers have obtained 100% stands of some of their small-seeded vegetables by the use of mulches.

The purpose of this study is to test various mulches and evaluate them as to their usefulness for stand establishment of small-seeded legumes in experimental work.

It is a common practice of farmers in Oklahoma to plant from 15 to 20 pounds of alfalfa per acre when a much lower seeding rate would suffice if a higher percentage of seedlings would emerge above the ground. The soil crust which occassionally forms is largely responsible for the reduced percentage of seedling emergence. The planting of alfalfa at the rate of 17.5 pounds per acre was included in this study in an attempt to ascertain whether additional seedlings would exert sufficient force against the crust to crack it and make it possible for a higher percentage of emergence than it would be at a lower rate of planting.

REVIEW OF LITERATURE

Jacks, Brind, and Smith (11)[1] report that the practice of mulching, well known to the gardener and, to a lesser extent, the farmer, is perhaps as old as agriculture itself. They add that the English word mulch, which has been used as a noun since the seventeenth century, is probably derived from the German vernacular molsch, meaning soft, beginning to decay. This, no doubt, referred to the gardener's use of a mixture of wet straw, leaves and loose earth spread on the ground to protect the roots of newly planted trees and shrubs. Since 1802 the practice of spreading a mulch on the soil surface has been referred to in English as mulching, they added. They report that generally a mulch is defined as any material used at the surface of a soil primarily to prevent loss of water by evaporation, to keep down weeds, to reduce temperature fluctuations or to promote soil productivity. They define it as the use of crop residues, manure, leaves, peat and other litter as well as paper, glass wool, metal foil, cellophane and other convenient manufactured materials used for the purpose of increasing soil productivity.

Earlier, (1928) Flint (9) stated that mulch might be defined as any artificial modification of the soil surface. Such modifications, he added, may be of considerable diversity; they include the soil mulch of ordinary cultivation, the straw mulch of special utility in strawberry culture, and the impervious paper mulch extensively used in the

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[1] Figures in parenthesis refere to "Literature Cited," page 21

pineapple industry of the Hawaiian Islands.

In 1948, Duley and Russel (3) reported that raindrops destroy the structure of the top of the soil and leave a compacted layer of about 1/16 inch on the surface which retards water intake. They found that water enters the soil during rains through the pores or spaces between the soil granules. As long as the pores are open, water may soak into the soil at a fairly rapid rate until the soil is so filled as to slow down further adsorption. However, they stated, if these pores at the surface become clogged or sealed over, the water cannot soak in rapidly. They found that if the land is bare so that the rain drops strike it directly, the soil granules are broken and the fine mud forms a seal over the surface.

Earlier in 1939, Duley and Kelly (4) stated that this compact layer apparently was formed through an alteration of the structure at the soil surface. This is brought about by the impact of rain and the further assortment of particles and the wedging and fitting of these into close formation by running water, all of which slows the entrance of water through the immediate surface. In order to prevent a surface seal from forming, the raindrops of a heavy rain must be kept from hitting the bare soil directly.

Duley and Russel (2) in 1942 concluded that it was possible to prevent the formation of a compacted layer on cultivated soil by protecting the surface, during rains, with crop residues. They also stated that crop residues would increase infiltration and improve the structure of the soil. Lemmon (12) reported similar findings.

Recently, Snider (16) noted something very similar to Duley and Russel. He reported that the very minute soil particles are hit by a beating rain they are separated and scattered instead of remaining in small clusters called aggregates. When the fine soil particles are separated and behave individually instead of in clusters, the top soil will become crusted when dry.

Ellison (5) agreed that this splash erosion process puddles surface soils and causes surface seals to be formed. He further stated these seals will cause most of the rainfall to run off. He added that surface sealing may also cause poor soil areation; it may destroy worm life and interfere with microbial action within a soil; and may impair land's productive capacity in other ways. In another paper Ellison (6) reported that the surfaces of many heavy textured soils are so easily sealed by the splash of high-velocity raindrops that more than 90% of their infiltration capacity may be destroyed during a few minutes of high-impact rain. He further stated that rain is more than water. It is water plus energy. This energy is enormous. It can be completely controlled by vegetative cover, he added, but if not so controlled it will cause many forms of erosional damage including puddle erosion.

In 1939, Franklin (10) concluded that mulching conserves moisture, protects and improves soil, and protects seedlings. He said that protection, by mulching or some other means, from drying sun and wind is particularly important during and immediately following seed germination to prevent loss of the young plants as the result of soil crusting or lack of moisture. Pew (14) made a similar statement in 1954.

Watson (18), too, stated in 1954 that the great retention of soil moisture was likely the most important benefit the plant received from the use of the mulching material. Emmerson (7) reported similar findings as early as 1900.

Some of the mulches that have been tried and proven successful in some respect include vermiculite, sheets of plastic, straw, chopped fodder, peat moss, and other organic substances. Pew reported (14) that when vermiculite was placed in a band $\frac{1}{2}$ inch deep and 1 inch wide over the seed row, he got an increase of 134.6% in the number of fall head lettuce plants as compared with untreated plants. He also said that other crops have worked successfully with this method. He has used it to obtain perfect stands of broccoli and cauliflower where precision is needed in experimental work. However, he added that vermiculite was not a cure-all and would not stay put under high winds or heavy rains.

Emmert (8) who worked some with sheet plastic in 1956 concluded that moisture stayed about 10 days longer under black plastic than it did on bare soil. He stated that it warmed the soil in the spring, and with vegetables, it caused them to come up sooner than those on bare soil. He pointed out that laying this plastic material was a problem. However, machines could be made that would lay it, if necessary. He reported that plastic sheets have been known to be used over again for as long as 4 years. Staff (17) stated that clear film conserves moisture but black film would control weeds when placed between plants.

McCalla and Duley (13) found that heavy mulches of straw have lowered the soil temperatures as much as 17.17° C. at one inch depth. In some crops during the heat of the summer, this could give valuable results.

It was reported by Woods, Hebb and Fassnacht (19) that in a mulch of long leaf pine straw the temperature within the mulch sometimes exceeded 160° F while the bare soil temperature was 143° F. However, the temperature under the mulch was as much as 59° F. cooler than the mulch temperature. They concluded that the mulch acted as a heat trap.

Contrary to the findings of Woods, et.al., Burnett and Fisher (1) have found that there was very little difference in the soil temperatures of mulched ground and bare ground. They did say, however, that the increase in available moisture as a result of mulch treatment was reflected in increased yields of lint cotton up to 69%.

MATERIALS AND METHODS

Two separate tests were conducted in studying the effect of various mulches on stand establishment of small-seeded legumes. The first test was planted October 5, 1956 on the Oklahoma State University Agronomy Farm west of Stillwater, Oklahoma. The second was planted May 7 and 8, 1957 at the same location.

The first test included four different small-seeded legumes and four different treatments. The legumes used were Kenland Red Clover, Trifolium pratense; Pilgrim Ladino Clover, Trifolium repens; Oklahoma Common Alfalfa, Medicago sativa; and Commercial Crimson Clover, Trifolium incarnatum. The mulches used were chopped corn stover, rye straw, black polyethylene plastic sheet and a check plot with no mulch.

Seed germination tests were conducted at the USDA Grass Seed Laboratory at Stillwater, Oklahoma on samples of each of the different legumes. Four samples of one hundred seeds each were taken at random from each of the legume varieties. Each of these 100 seed samples was then placed in small plastic germination boxes between blotters and put into a Shults Germinator at 20° C. Two counts were made. One was made after four days and another was made after seven days in the germinator. The average percentage of germination for each of the varieties was then calculated. This in turn was employed in the determination of the number of seeds to be planted per row in the field. The seedling rate was calculated so that one pure live seed would be planted every two inches. This made 120 pure live seeds in each of the 20 feet rows.

The germination percentages and seeding rates of each of the varieties may be found in the appendix in Table III. Two different rates of alfalfa were planted. One was as described in Table III and the other was 2.5 grams per row. This is equivalent to 12.5 pounds per acre. The purpose of this higher rate of seeding was to study the effect of the expected increased exertion from many seedlings breaking the soil crust. In this experiment the high rate of seeding was treated as another variety. It was given all the mulch treatments and carried in every replication just as were the different varieties.

Each plot consisted of two rows, 20 feet long, spaced one foot apart. They were arranged in a randomized block design with four replications. A belt seeder was used to plant the seeds to assure a uniform spacing of seeds in the row. All varieties were planted approximately ½ inch deep in the soil. Before seeding, the entire area of the experiment was sprinkle irrigated so that the soil received the equivalent of approximately four inches of rain.

After planting, the mulches were put on the plot immediately. The plastic was cut into strips just large enough to cover the plot without covering adjacent plots. It was held in place with spike nails pushed through large cardboard washers. The straw was so placed that it was about an inch thick over the entire plot. The stover was chopped into pieces about ½ to 3/4 of an inch long and placed in a band about an inch think and 5 inches wide over each row. Then it was necessary to cover the stover with burlap material to keep it from blowing. The burlap, too, was held down with spike nails. The check plot was left bare.

As soon as all of the mulches were put in place, the plots were irrigated again until the check plots had puddled. Beginning November 1, and ending November 3, 1956, counts were made on each plot and the number of plants per plot was determined. The counts were made for 2½ feet lengths alternately in the two rows. This gave four counts, each from 2½ feet length, from each of the two rows in the plot. The counts of the plots can be found in the appendix in Table V.

A second test was conducted as the results obtained from the first one were not indicative due to many variables. This will be discussed in detail in the section on RESULTS AND DISCUSSION.

The second experiment was conducted in flats, 14 inches by 20 inches to allow covering during inclement weather. Also, there were some modifications on the mulches as well as the legume varieties used.

The mulches were modified based upon observations made in the first experiment. Instead of only the black plastic, this second experiment contained clear plastic as well. The chopped fodder was excluded from this test. In its place, peat moss was substituted. The rye straw was used again, but the density was greatly reduced.

In the second experiment, because of the limited space, only two varieties of legumes were used. Alfalfa was seeded at two different rates making a total of three different seedings per flat. The other legume chosen for this test was ladino clover. Ladino clover was used because of its small seed in contrast to the alfalfa.

Percent germination of each variety was determined prior to planting.

Spacings of 1½ inches were allowed between seedlings in the rows in the flats with rows an inch apart. Each plot consisted of six rows, 14 inches long. This gave space for 56 pure live seeds per plot except for the double rate alfalfa which was 112 seeds.

The heavier seeding rate of alfalfa was planted in a single row, 14 inches long. There were 3 inches between that row and the nearest rows from the other plots.

For this test, a split plot design was used with six replications. The percentages of germination and seeding rates per plot can be found in the appendix in table IV.

A Kirkland silt loam soil was used in this test. Prior to planting the flats were irrigated and the soil moisture brought to field capacity. Seeding was done by hand. Three of the replications were planted in the afternoon of May 7 and the other three were planted in the morning of May 8, 1957. The mulches were placed on each of the replications the same day as the seeds were planted.

Here again, the two plastics were cut in strips to fit each flat and held in place with large spikes. The peat moss was placed on the soil from 1/8 to 3/8 inch deep. The straw was scattered over the top of the soil in a thin layer. The check plot was left with no cover. The individual plots, with the exception of those covered with plastic, were then sprinkled with a garden sprinkler can to simulate a rain of $\frac{1}{2}$ inch. This was enough to cause puddling on the bare soil.

A plastic canopy was prepared so that it could be placed over the flats in the event of rain. When in place, this canopy was off the ground about 8 inches so the wind could move across the soil surface.

In this test, the black plastic was removed as soon as some of the older seedlings appeared to show sign of etiolation. This varied from two days to four days among the different replications. The clear plastic was allowed to remain on the flats until the nineth day after they were planted. This coincided in part with the procedure set forth in "Rules for Testing Seeds Adopted by the Association of Official Seed Analysts."

These seedlings were allowed to grow for two weeks after planting. At this time, counts were made of all seedlings in each flat to determine the results of the various treatments. These counts may be found in the appendix in Table VI.

RESULTS AND DISCUSSION

The first trial was not considered a satisfactory test of experimental treatments. Immediately after planting and for the next two weeks, it rained frequently. The ground never dried enough to cause a crust formation on any of the plots. Therefore, little data of any value were obtained on the effect of various mulches from that test. However, some observations were made on the behavior of the plants, under different mulches, that were helpful in designing the second test.

In the first test the black plastic was left on the plants too long and many of them were elongated and etiolated when it was removed. After the removal of the plastic, the seedlings were so frail the wind broke many of them off at the ground. However, at the time the plastic was removed there was a good stand of legumes, but many of them did not survive.

It was also noted that the straw mulch was placed on much too thick. Many of the small seedlings were unable to penetrate the thick layer of straw and therefore were lost. The straw also posed another detrimental problem in that it contained viable rye seeds which came up in a short while and competed with the legumes.

The chopped fodder was light weight and it blew easily unless held by some means. Therefore, it was necessary to moisten it thoroughly before applying it on the plots. It was covered immediately with burlap to keep it in place after drying.

These observations were all considered before planting the second test, and it was altered to make the test more informative.

In the second test, it was found that the peat moss, which was moistened after application, stayed on the surface very well even after it had dried. The straw remained in place in a satisfactory manner after it had once been moistened.

It was noted that the stands were quite uniform under the peat moss and straw mulches, but under the plastic mulches, they tended to be quite thin and irregular just as they were in the check plots.

It was further noted that the plants under the clear plastic appeared unhealthy and some of them actually turned white and died.

The analysis of variance for the second test showed a significant interaction between the treatment and the legume. (See Table I) This indicates the mulches reacted differently on each of the different legumes.

The treatments used in this study were found to be significantly different. It was also found that there was a significant difference in the varieties, but this is to be expected because all of the seedlings were analyzed as different varieties, and the alfalfa was planted at a double rate making it obvious that there would be a difference in varieties.

Figure 1 is the graph of the interaction found. From this graph, it can be noted that with the two plastic mulches, the alfalfa and ladino clover act very much alike. This study indicates alfalfa produces a better stand when mulched with peat moss than it does with straw. To the contrary, ladino clover produces a much better stand with straw than it does with the peat moss. It is not known what is the cause of this. It is suspected that possibly the peat moss produced a

TABLE I

ANALYSIS OF VARIANCE OF LEGUME SEEDLING EMERGENCE AS AFFECTED BY VARIOUS MULCHES

Source	D.F.	S.S.	M.S.	F
Total	89	32480.4889		
Reps.	5	1590.7555	318.1511	
Treatment	4	13837.6000	3459.4000	24.67**
Error (a)	20	2804.8002	140.2400	
Varieties	2	11845.0889	5922.5444	320.79**
Var. x Treat.	8	1479.1335	184.1335	10.02**
Error (b)	50	923.1108	18.4622	

** Denotes significance of the F test at the 1% level

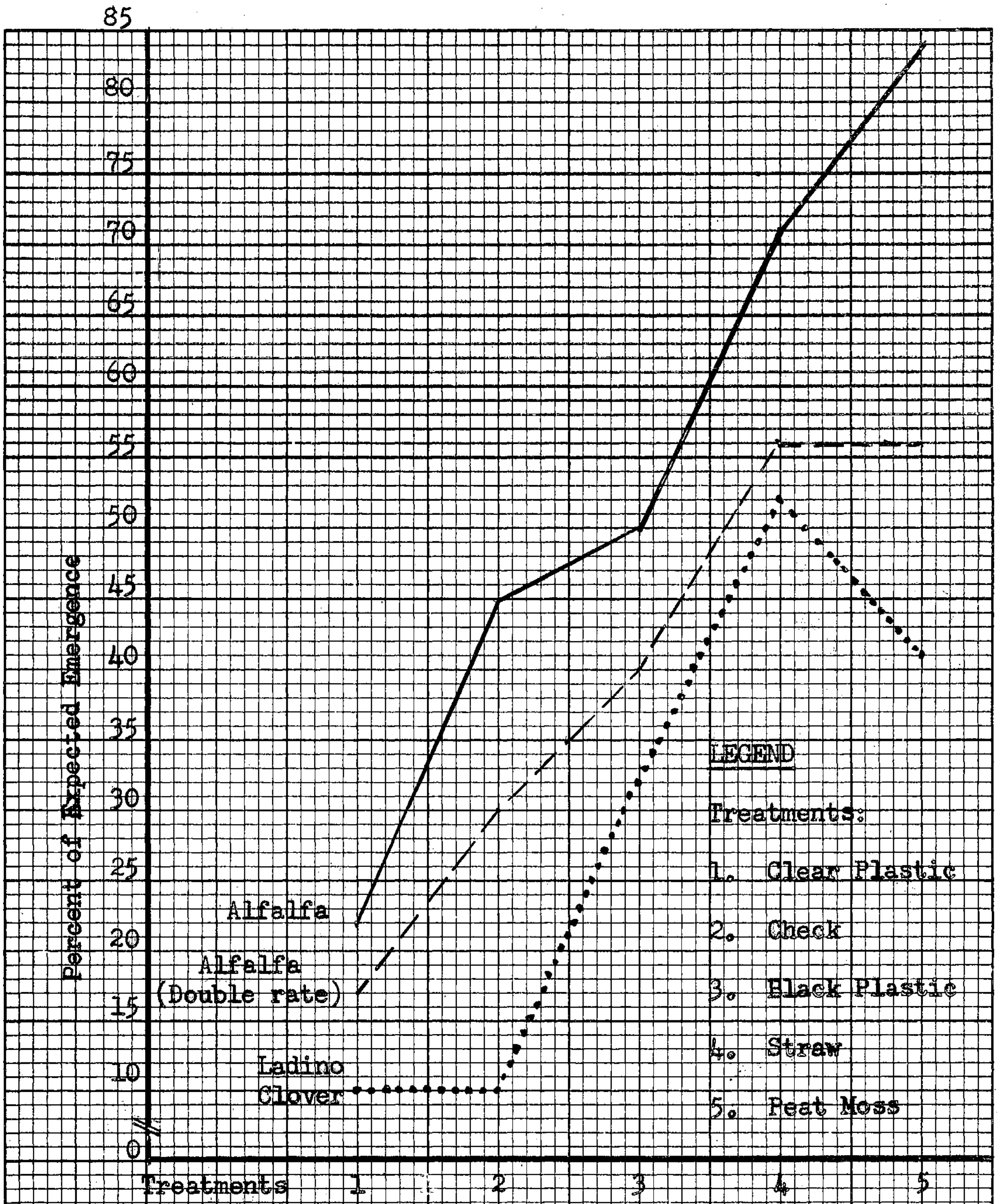

FIGURE 1

PERCENTAGE OF LEGUME SEEDLING EMERGENCE OBTAINED BY THE USE OF VARIOUS MULCHES a pH which was toxic to ladino seedlings. The pH values of the solutions produced from peat moss solution had a pH value of 3.9 as compared with the straw solution pH of 6.9. This appears to be an indication of the cause of the poor stand.

In this study it was found that the doubling of the seeding rate based on pure live seed of alfalfa did not increase the percentage of seedlings which emerged. In no case was the percentage obtained equal to the lesser rate of planting. (See Table II) It is not known what is the cause for this. Further investigation of this decrease in seedling emergence appears to be in order.

TABLE II

PERCENTAGE OF LEGUME SEEDLING EMERGENCE OBTAINED BY THE USE OF VARIOUS MULCHES

	Treatments				
Legume	Check	Clear Plastic	Black Plastic	Peatmoss	Straw
Ladino	10	10	32	41	52
Alfalfa	45	22	50	84	71
Alfalfa (Double rate)	30	17	40	56	56

SUMMARY

Two tests were planted in 1956 and 1957 at the Oklahoma State University Agronomy farm at Stillwater, Oklahoma to test various mulches as to their usefulness in stand establishment of small-seeded legumes. It was decided to discard all data from the first test as frequent rains prevented the formation of a crust on the soil surface which was necessary in this study.

The mulches used in the second test were peat moss, clear plastic, black plastic and straw. The legumes used were ladino clover and alfalfa. The alfalfa was planted at two different rates. The first rate was the same as the ladino clover. The second rate was equivalent to 17.5 pounds per acre which was exactly double the first rate. The purpose for this second rate of planting was to determine if by planting at a heavier rate the expected larger number of seedlings would be able to exert more pressure on the soil crust thereby breaking it and allowing a higher percentage of them to emerge.

A significant difference was found between the treatments. It was also found that there was significant interaction between some of the mulches and some of the legumes. It was found that alfalfa produced a better stand with peat moss than the other three mulches tested. It was also noted that straw gave a better stand than did peat moss when used with ladino clover.

The acidity of solutions formed by these mulches was tested, and it was found that the peat formed a solution with a pH of 3.9 whereas the straw formed a solution with a pH of 6.9.

It was further noted in the experiment that the planting of alfalfa at the double planting rate did not increase the percentage of seedlings which emerged from the soil. In fact, in no case was the percentage as high as it was when it was planted at the lower rate.

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A P P E N D I X

TABLE III

THE PERCENT GERMINATION AND CALCULATED SEEDING RATES FOR EACH OF THE LEGUMES USED IN THE FIRST TEST.

Legume	Percentages germination	Number of seeds required per row to obtain 120 pure live seeds
Red Clover	88.75	135
Alfalfa	79.25	151
Crimson Clover	72.50	165
Ladino Clover	71.50	168

TABLE IV

THE PERCENT GERMINATION AND CALCULATED SEEDING RATES FOR EACH OF THE LEGUMES USED IN THE SECOND TEST.

Legume	Percentages germination	Number of seeds required per plot for 56, 56, and 112 pure live seeds, respectively
Ladino Clover	65.00	86
Alfalfa	94.67	59
Double rate Alfalfa	94.67	118

TABLE V

DATA OBTAINED FROM THE FIRST FIELD EXPERIMENT PLANTED OCTOBER 6, 1956

CODE: I - Black Plastic
II - Straw
III - Chopped Stover
IV - Check

Variety	Treatment	Replications 1	2	3	4
Crimson Clover	I	66	60	64	20
	II	30	32	36	60
	III	10	74	78	54
	IV	100	74	78	72
Red Clover	I	160	110	90	74
	II	134	124	114	82
	III	168	126	104	72
	IV	194	174	164	154
Ladino Clover	I	88	94	100	112
	II	70	28	82	40
	III	48	84	38	128
	IV	122	126	192	134
Alfalfa	I	122	72	100	36
	II	134	68	104	86
	III	100	106	74	70
	IV	150	130	144	142
Alfalfa (Second rate)	I	474	494	504	178
	II	224	346	192	374
	III	664	458	322	440
	IV	752	902	848	678

TABLE VI

FIELD DATA OF SECOND TEST OBTAINED FROM FLATS PLANTED MAY 7 AND 8, 1957

CODE: A - Check
B - Clear Plastic
C - Black Plastic
D - Peat Moss
E - Straw

( ) Indicates calculated for missing data.

Variety	Treatment	Replications 1	2	3	4	5	6	Total
Ladino Clover	A	13	6	6	2	2	4	33
	B	3	9	2	1	17	0	32
	C	49	24	4	11	6	(13)	107
	D	30	24	(21)	20	21	22	138
	E	23	37	40	28	25	22	175
	Total	118	100	73	62	71	61	485
Alfalfa	A	32	29	29	24	18	19	151
	B	20	4	9	8	17	18	76
	C	38	36	29	23	18	(23)	167
	D	50	49	(47)	46	45	44	281
	E	43	44	38	40	37	36	238
	Total	183	162	152	141	135	140	913
Alfalfa (Double rate)	A	39	56	22	61	12	14	204
	B	9	13	29	9	22	29	111
	C	62	63	30	22	55	(37)	269
	D	74	68	(58)	58	62	54	374
	E	68	68	66	59	54	55	370
	Total	252	268	205	209	205	189	1328

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