THE EFFECT OF ROW SPACING AND TYPE OF MOWER ON FORAGE PRODUCTION OF THREE VARIETIES OF WINTER OATS

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TABLE OF CONTENTS

LIST OF TABLES

Table		Page

Table Page

LIST OF APPENDIX TABLES

LIST OF FIGURES

INTRODUCTION

Various studies have shown that plants are modified by the space available for their growth and development. Experiments conducted with cotton, corn, sorghums, grasses and small grains have demonstrated the effect of spacings between plants on their development and yield. Since most of the row spacing work on small grains has dealt with grain yields, only a limited amount of information is available regarding the optimum row spacing for maximum forage yields. Additional information would be especially helpful to livestock producers who utilize small grains entirely for pasture.

Two types of mowers, rotary and sickle, have been used in harvesting forage yields of small grains in experimental work at the Oklahoma Agricultural Experiment Station. Data obtained from a comparison of the two types of mowers would be useful in determining which type might best be utilized in further experimental work.

The primary objective of this study is to determine the effect of row spacing and type of mower on forage yield of three varieties of winter oats which represent upright, intermediate and prostrate type of growth habit.

LITERATURE REVIEW

A considerable amount of work has been done regarding the forage production of small grains. Redding (16) [1] in 1899 reported that rye and barley were being utilized almost exclusively for pasture and green manure crops. The early sowing of small grains for greater forage production was recommended. From Louisiana, Dobson (5) reported that barley sown early grew as rapidly as oats and made very good pasture. It was further stated that rye furnished excellent grazing the entire winter.

Staten and Heller (20) reported that livestock producers might profitably utilize the crop entirely for pasture without taking a grain crop. Forage production of various varieties differed enough to make it worthwhile to choose a variety specifically for pasture when the crop was to be grazed extensively.

In studies with oats, Crowder (4) reported that increased forage yields could be obtained by planting earlier than the recommended date for grain production. Complete utilization of the

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[1] Figures in parenthesis refer to Literature Cited.

cereal grain as a grazing crop was recommended if the grain was not needed. After extensive study on winter pasture crops for Georgia, Burton et al. (2), found that winter pasture from small grains could be increased by planting good forage varieties. Early planting was also recommended.

Kirk et al. (11), reported cereal grains were capable of providing good pasturage in many parts of Canada. Oats were by far the most important of the small grains. Young oat herbage was regarded as a highly concentrated protein feed.

Schwartzbeck (18) in studies with irrigated oats in Texas, found that forage production increased consistantly as the rate of seeding increased and as row width was decreased. The highest total production was obtained by using a combination of six inch row spacing and a seeding rate of four bushels per acre.

The effect of row spacing on the growth and yield of oats and red clover was determined by Dungan and Pendleton (7) in Illinois. The data obtained showed that yields of grain and straw were inversely proportional to the area between rows. Eight inches was the optimum row spacing. Kaukis and Reitz (10) studied the effect of spacing on grain yield of five varieties of spring oats. The plants were spaced 2.5 and 5.0 inches apart in 7-inch rows. The highest yield per plant was produced under the 5-inch spacing.

Sander (17) conducted experiments with bromegrass strains grown in different row spacings. He reported that when moisture was abundant, the width of row spacing with which highest yields were obtained depended on the amount of available nitrogen present.

He further stated that in dry seasons, competition for moisture was the main factor in determining yields.

Results of millet spacing trials by Li and Meng (13) showed that highest yields were obtained when the rows were spaced twelve inches apart and the plants were spaced two to four inches apart within rows.

According to Brandon (1), the highest yield of corn in the West Central Great Plains was obtained when plants were spaced twenty-four inches apart within rows and the rows were spaced forty-four inches apart.

Cotton spacing studies by Mayton (14) in Alabama showed that highest yields were obtained when plants were spaced eighteen inches apart within rows and the rows spaced two and one-half to four and one-half feet apart.

In a series of experiments conducted in Texas, Edwards (8) stated that the grain sorghums produce highest yields of both forage and grain with a stand of one plant every four to eight inches in the row. Sorgos produced the best yields, considering both quality and quantity of forage, with plants from two to four inches apart in the row.

Experiments by Clements et al. (3), on competition within stands of wheat of varying thickness indicated the relative importance of moisture and plant nutrients as environmental factors affecting growth. The data obtained showed that growth was greatest when both water and nutrients were adequate, and that growth was least when both of these factors were deficient. When water alone was limiting, growth was retarded nearly as much as by a deficiency of both water and nutrients.

Kmoch et al. (12), studied the root development of winter wheat as influenced by soil moisture and nitrogen fertilization. It was found that under favorable conditions, roots reached a depth of 13 feet with moisture depletion to eight feet. Nitrogen fertilization increased root weights and moisture utilization at all moisture levels.

The effect of nitrogen fertilization on the forage yields of small grains was studied by Morris and Gardner (15). High nitrogen fertilization consistently increased yield over low nitrogen fertilization. Nitrogen content of forage was increased significantly by the higher nitrogen fertilization.

In clipping experiments with small grains, Harper and Hubbard (9) found that severe clipping produced slightly less forage and considerably less grain than moderate clipping. Cereals were not affected by severe clipping as much in favorable growing seasons as in unfavorable ones. Forage from severely clipped plots had similar chemical composition as forage from moderately clipped plots.

Studies were conducted by Wallace and Chapman (21) to determine optimum plot size for small grain clipping experiments. They stated the best plot size was one row, eight feet long, replicated four or five times.

MATERIALS AND METHODS

A study to determine the effect of row spacing and type of mower on forage yields of three varieties of winter oats was conducted at the Agronomy Research Station, Stillwater, Oklahoma in 1958-1959 on a Kirkland silt loam soil.

Three varieties of winter oats (Arkwin, Bronco and Wintok) representing upright, intermediate and prostrate type of growth habit, respectively, were seeded at an equivalent rate based on pure live seed in three row spacings (3, 6 and 12 inches). Two types of mowers (rotary and sickle) were used to harvest the forage. The various treatments are shown in Table I.

The field layout consisted of a randomized block design with three replications. Each plot was three feet wide and 20 feet long. Plots in which 12-inch row spacing was used contained three rows. The center row of these plots was harvested for forage yield determination. Plots in which 6- and 3-inch row spacing was used contained 6 and 12 rows, respectively. In those plots containing 6 or 12 rows, one-half of the rows were harvested.

The plots were seeded with a Planet Jr., one-row, push-type planter on September 8, 1958. The number of pure live seed per unit weight was determined for each variety and adjusted to plant

TABLE I

ROW SPACING AND TYPE OF MOWER USED IN STUDYING THE FORAGE PRODUCTION OF THREE VARIETIES OF WINTER OATS AT STILLWATER, OKLAHOMA, 1958 - 1959

Treatment	Variety	Row Spacing	Type of Mower
1.	Arkwin	12 inches	Sickle
2.	Arkwin	3 inches	Rotary
3.	Arkwin	6 inches	Sickle
4.	Wintok	12 inches	Sickle
5.	Wintok	3 inches	Sickle
6.	Wintok	6 inches	Rotary
7.	Bronco	12 inches	Rotary
8.	Bronco	3 inches	Rotary
9.	Bronco	6 inches	Rotary
10.	Arkwin	12 inches	Rotary
11.	Arkwin	3 inches	Sickle
12.	Arkwin	6 inches	Rotary
13.	Wintok	12 inches	Rotary
14.	Wintok	3 inches	Rotary
15.	Wintok	6 inches	Sickle
16.	Bronco	12 inches	Sickle
17.	Bronco	3 inches	Sickle
18.	Bronco	6 inches	Sickle

an equal number of seed in each plot. Wintok, Bronco and Arkwin were seeded at 2.0, 2.2 and 2.6 bushels per acre, respectively.

By using only two-thirds of the forage yield from those plots where one-half of the rows were harvested, the plot yields were put on a comparable basis with regard to plant population with those where one-third of the rows were harvested.

Two inches of supplemental water was applied immediately after seeding by sprinkler irrigation to insure germination of the seed in the dry seed bed. Additional irrigations of 1.5 inches each were made on October 7, October 26 and March 18.

The area was fertilized the day of planting with 25-30-0 fertilizer at the rate of 200 pounds per acre. Additional nitrogen was applied by broadcasting in the form of commercial 33% ammonium nitrate at the rate of 150 pounds per acre on October 6 and again on March 18.

The plots were harvested when the forage attained a height of at least 4 inches. The harvested forage was oven-dried at a temperature near 140° Fahrenheit in a forced air oven. After the dry weights were recorded, a random sample from each plot was taken to the Department of Biochemistry for crude protein determination.

Due to an infestation of greenbugs (<u>Toxoptera graminum</u>), the area was sprayed on April 1 with a solution of Malathion. Slight injury had occurred before the application was made with Wintok apparently being damaged more than either Arkwin or Bronco.

Statistical analyses of the data were conducted as outlined by Snedecor (19) and Duncan (6).

RESULTS AND DISCUSSION

When analyzed by statistical methods, each periodic forage clipping showed a highly significant difference among treatments. The multiple range tests are shown in Tables II through VI. Analyses of variance are shown in Appendix Tables I through V.

Due to an error in clipping procedure, the data from the first clipping were discarded. As a result, it is possible that a variety such as Arkwin which makes its greatest growth in the fall might rank somewhat higher in total production if all clipping data were available.

Data from the November 4 clipping, as shown in Table II and Appendix Table I, indicate that the highest production was obtained by using the rotary mower on the 12-inch spacing of Wintok and Bronco and either the 3-, 6- or 12-inch spacing of Arkwin. The rotary mower obtained the most forage regardless of spacing with the 12-inch spacing producing considerably more than the 3- or 6-inch spacing as shown in Figure 1.

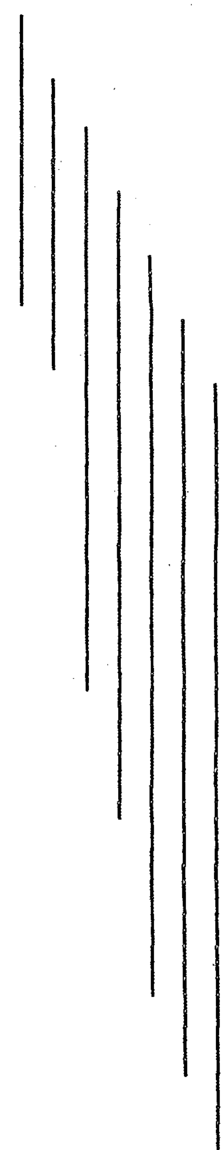
The March 31 clipping (Table III and Appendix Table II) showed a highly significant difference between mowers, with rotary clipped treatments again producing the most forage.

TABLE II

MULTIPLE RANGE TEST OF THE OVEN-DRY FORAGE YIELDS IN GRAMS FROM THE NOVEMBER 4, 1958 HARVEST

Treatment			Mean Yield Grams
Bronco	12"	Rotary	133
Arkwin	12"	Rotary	128
Wintok	12"	Rotary	114
Arkwin	6"	Rotary	100
Arkwin	3"	Rotary	95
Bronco	6"	Rotary	90
Arkwin	6"	Sickle	86
Bronco	3"	Rotary	82
Arkwin	12"	Sickle	81
Wintok	3"	Rotary	80
Wintok	6"	Rotary	79
Arkwin	3"	Sickle	70
Bronco	6"	Sickle	66
Bronco	12"	Sickle	57
Wintok	6"	Sickle	56
Wintok	3"	Sickle	54
Bronco	3"	Sickle	51
Wintok	12"	Sickle	44

Multiple Range /x



/x Any two means underscored by the same line are not significantly different at the 5% level.

TABLE III

MULTIPLE RANGE TEST OF THE OVEN-DRY FORAGE YIELDS
IN GRAMS FROM THE MARCH 31, 1959 HARVEST

Treatment			Mean Yield Grams	Multiple Range /x
Bronco	12"	Rotary	149	
Wintok	12"	Rotary	130	
Wintok	3"	Rotary	108	
Arkwin	12"	Sickle	95	
Arkwin	3"	Rotary	94	
Arkwin	6"	Rotary	86	
Bronco	12"	Sickle	85	
Bronco	3"	Rotary	79	
Wintok	6"	Rotary	76	
Bronco	6"	Rotary	73	
Arkwin	12"	Rotary	73	
Wintok	3"	Sickle	60	
Wintok	12"	Sickle	58	
Arkwin	3"	Sickle	43	
Wintok	6"	Sickle	40	
Bronco	6"	Sickle	26	
Bronco	3"	Sickle	20	
Arkwin	6"	Sickle	18	

/x Any two means underscored by the same line are not significantly different at the 5% level.

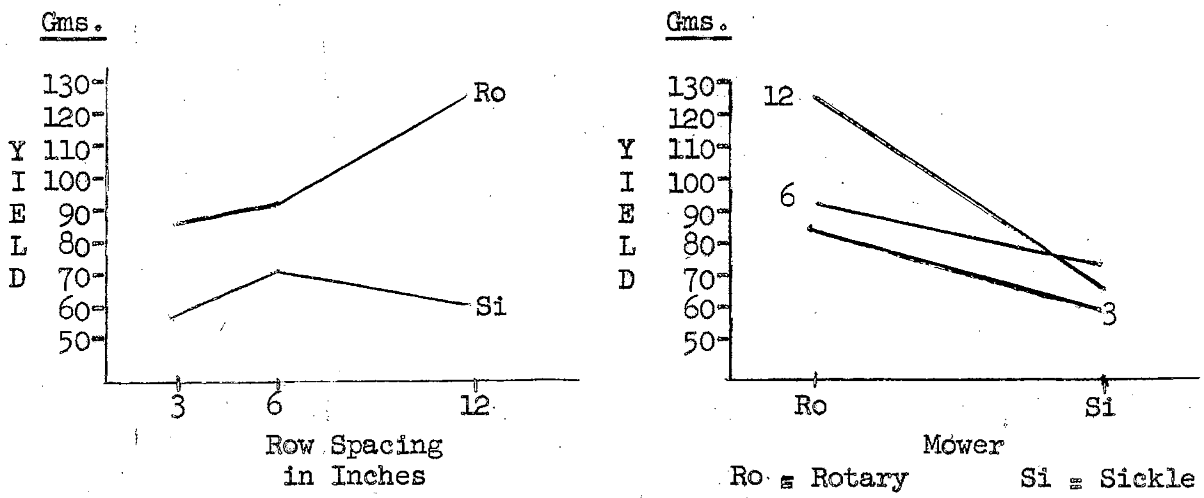


FIGURE 1. Average yields of oven-dry forage in grams from the November 4, 1958 harvest.

The sickle clipped treatments produced the most forage in the April 24 harvest (Table IV and Appendix Table III). This exchange in rank by rotary and sickle clipped plots may be attributed to one or more factors. The young prostrate forage seems to escape the sickle mower while the rotary mower, due to a suction created by the whirling blade, is able to pick up a considerable amount. Thus there is reason to expect the rotary clipped plots to produce more in the early part of the season. Later in the season, with nearly all growth being upright, both types of mowers should be on an equal basis. Another factor to be considered is the possibility that the rotary mower, while gleaning more forage early in the season, may injure the young plants to such an extent that their recovery would not be as rapid or complete as sickle clipped plants. As shown in Figure 2, the 12-inch spacing produced the most when clipped with

TABLE IV

MULTIPLE RANGE TEST OF THE OVEN-DRY FORAGE YIELDS IN GRAMS FROM THE APRIL 24, 1959 HARVEST

Treatment			Mean Yield Grams	Multiple Range /x			
Wintok	3"	Sickle	428	│			
Arkwin	3"	Sickle	385	│	│		
Wintok	6"	Sickle	356	│	│	│	
Bronco	3"	Sickle	315	│	│	│	│
Arkwin	12"	Sickle	308	│	│	│	│
Wintok	12"	Rotary	304	│	│	│	│
Bronco	6"	Sickle	303	│	│	│	│
Arkwin	6"	Sickle	300	│	│	│	│
Wintok	12"	Sickle	300	│	│	│	│
Bronco	12"	Rotary	288		│	│	│
Bronco	12"	Sickle	265		│	│	│
Arkwin	3"	Rotary	246		│	│	│
Wintok	3"	Rotary	239			│	│
Arkwin	12"	Rotary	236			│	│
Bronco	6"	Rotary	205				│
Wintok	6"	Rotary	204				│
Arkwin	6"	Rotary	197				│
Bronco	3"	Rotary	176				│

/x Any two means underscored by the same line are not significantly different at the 5% level.

the rotary mower and the least when harvested with the sickle mower.

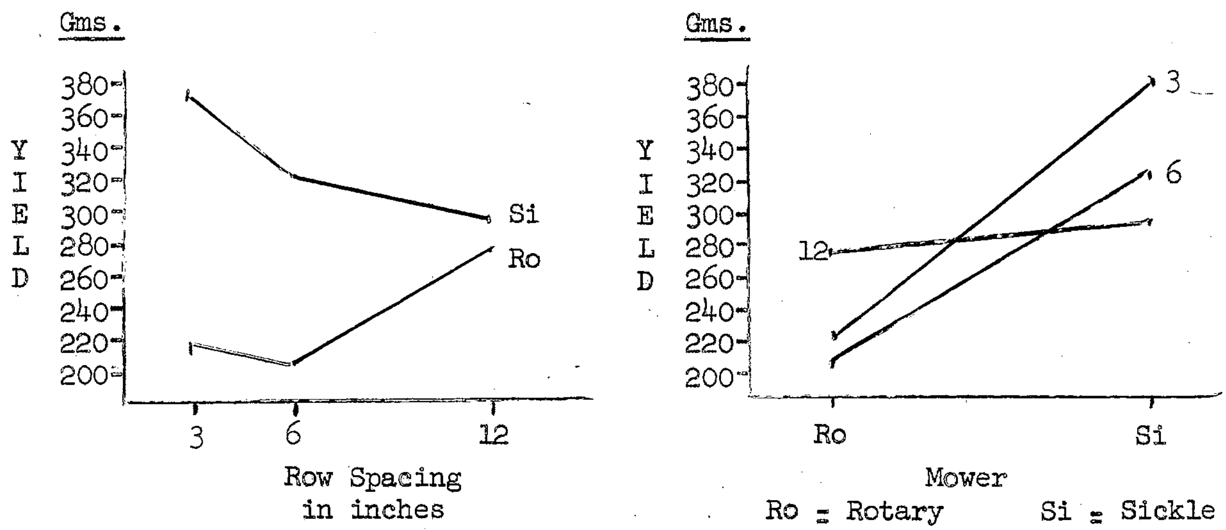


FIGURE 2. Average yields of oven-dry forage in grams from the April 24, 1959 harvest.

When the plots were clipped on May 14, the treatments harvested with the sickle mower again yielded the most forage (Table V and Appendix Table IV). Bronco was the best variety. Figure 3 shows that the rotary mower again obtained considerably more forage from the 12-inch spacing than from the 3- or 6-inch spacing. Data in Figure 4 indicate that the sickle mower obtained only slightly more forage of Arkwin and Wintok than the rotary mower. The sickle mower, however, obtained a much greater amount of forage of Bronco than the rotary mower.

Results of total accumulated forage production are shown in Table VI and Appendix Table V. The data obtained indicate that all three varieties were high producers when seeded in 3-inch spacing and harvested with the sickle mower. When harvested with the sickle

TABLE V

MULTIPLE RANGE TEST OF THE OVEN-DRY FORAGE YIELDS IN GRAMS FROM THE MAY 14, 1959 HARVEST

Treatment			Mean Yield Grams	Multiple Range /x
Bronco	3"	Sickle	404	
Bronco	12"	Sickle	350	
Bronco	6"	Sickle	320	
Bronco	12"	Rotary	251	
Bronco	3"	Rotary	200	
Bronco	6"	Rotary	173	
Arkwin	12"	Rotary	169	
Wintok	3"	Sickle	168	
Wintok	6"	Sickle	165	
Arkwin	12"	Sickle	149	
Arkwin	6"	Sickle	148	
Wintok	12"	Sickle	139	
Arkwin	3"	Sickle	138	
Wintok	12"	Rotary	138	
Wintok	6"	Rotary	123	
Arkwin	6"	Rotary	93	
Wintok	3"	Rotary	90	
Arkwin	3"	Rotary	75	

/x Any two means underscored by the same line are not significantly different at the 5% level.

mower, Bronco was a high producer at all three spacings. When harvested with the rotary mower the 12-inch spacing yielded much higher than either the 3- or 6-inch spacing (Figure 5).

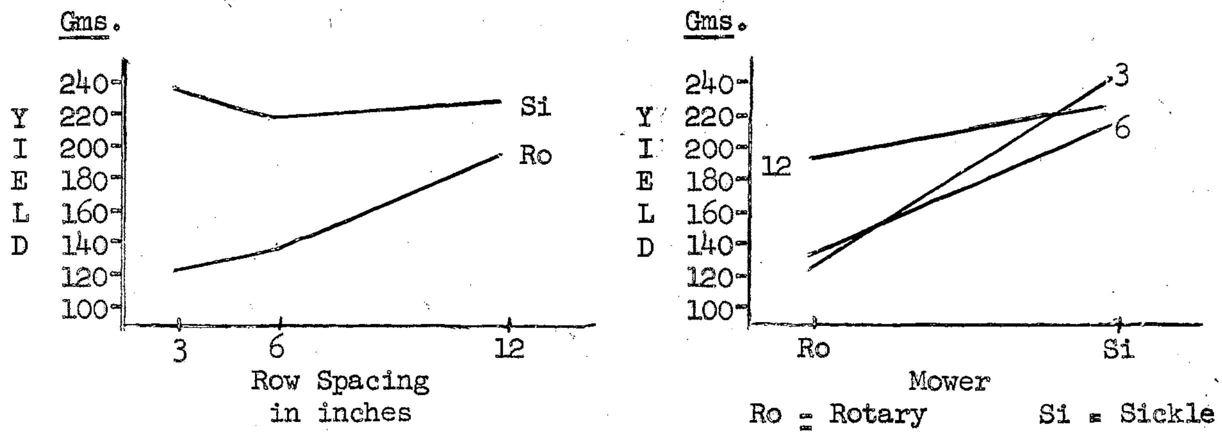


FIGURE 3. Average yields of oven-dry forage in grams from the May 14, 1959 harvest.

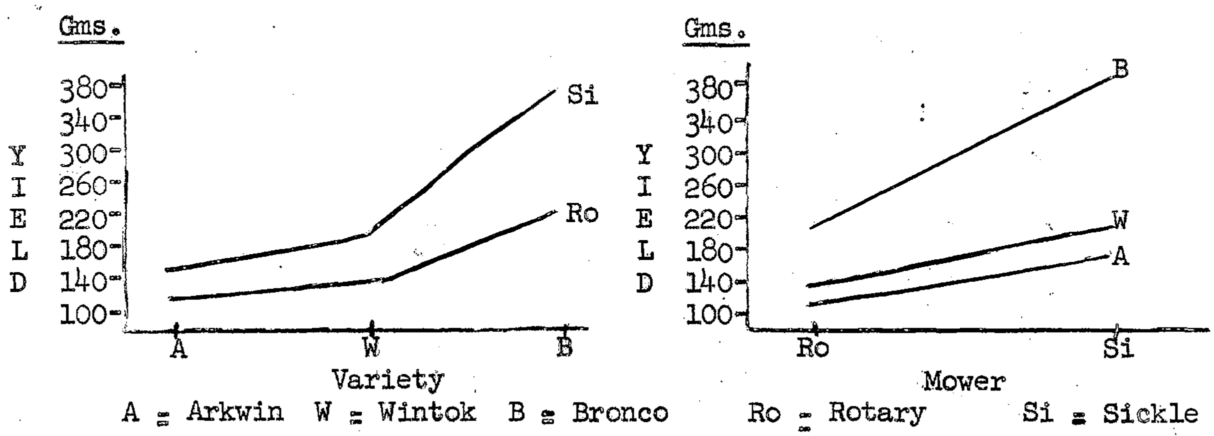


FIGURE 4. Average yields of oven-dry forage in grams from the May 14, 1959 harvest.

TABLE VI

MULTIPLE RANGE TEST OF THE TOTAL ACCUMULATED OVEN-DRY FORAGE YIELDS IN GRAMS

Treatment			Mean Yield Grams	Multiple Range /x
Bronco	12"	Rotary	820	
Bronco	3"	Sickle	790	
Bronco	12"	Sickle	756	
Bronco	6"	Sickle	715	
Wintok	3"	Sickle	710	
Wintok	12"	Rotary	686	
Arkwin	3"	Sickle	636	
Arkwin	12"	Sickle	632	
Wintok	6"	Sickle	618	
Arkwin	12"	Rotary	605	
Arkwin	6"	Sickle	552	
Bronco	6"	Rotary	541	
Wintok	12"	Sickle	541	
Bronco	3"	Rotary	537	
Wintok	3"	Rotary	517	
Arkwin	3"	Rotary	510	
Wintok	6"	Rotary	482	
Arkwin	6"	Rotary	475	

/x Any two means underscored by the same line are not significantly different at the 5% level.

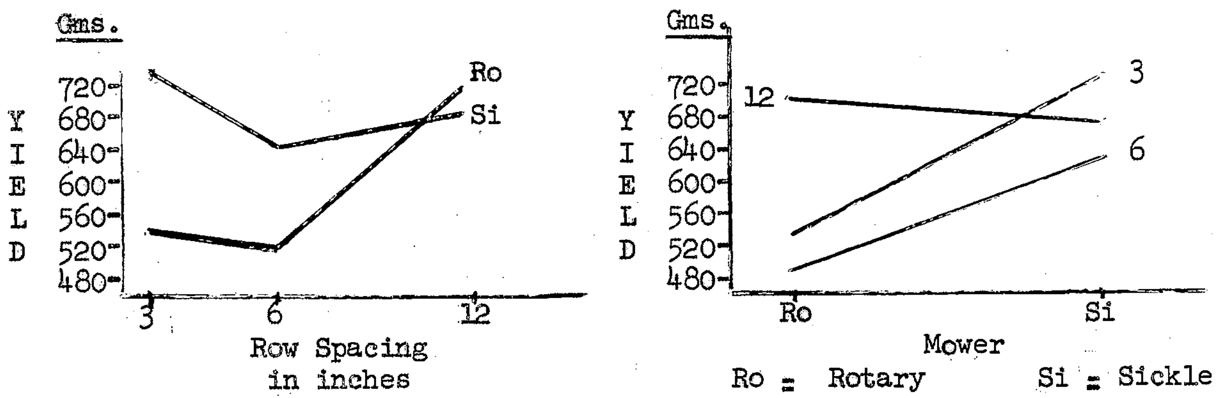


FIGURE 5. Accumulated average yields of oven-dry forage in grams.

The average protein percent was relatively high in all treatments as shown in Table VII. Protein percent was calculated on an insoluble ash free basis because of the large amount of insoluble ash in the samples (Tables VIII through XIX). Analysis of variance and multiple range tests were applied to the insoluble ash percentages of the forage yields by harvests. Data obtained from the November 4 harvest indicate a highly significant difference between mowers, with the rotary clipped samples containing the greatest amount of insoluble ash (Table XX and Appendix Table VI).

Those samples harvested with the rotary mower contained the highest percent of insoluble ash in the March 31 clipping (Table XXI and Appendix Table VII). Insoluble ash percentages increased as row spacing increased. Arkwin was the highest variety. Perhaps this results from the upright habit of growth of Arkwin which leaves more soil surface exposed to the suction created by the rotary mower.

As shown in Table XXII and Appendix Table VIII, rotary clipped samples contained the highest amount of insoluble ash in the April 24 harvest.

TABLE VII

AVERAGE CRUDE PROTEIN PERCENT OF WINTER OAT FORAGE BY HARVESTS CALCULATED ON AN INSOLUBLE ASH FREE BASIS

Treatment			Harvest Period			
			Nov. 4	Mar. 31	April 24	May 14
Arkwin	12"	Sickle	30.05	27.01	18.25	15.88
Arkwin	3"	Rotary	29.01	25.82	18.71	17.29
Arkwin	6"	Sickle	31.23	30.56	18.71	14.44
Wintok	12"	Sickle	33.43	25.10	15.56	12.32
Wintok	3"	Sickle	33.45	23.54	16.09	13.25
Wintok	6"	Rotary	33.54	26.90	22.39	17.70
Bronco	12"	Rotary	32.61	28.37	23.33	17.62
Bronco	3"	Rotary	30.93	26.59	19.99	14.79
Bronco	6"	Rotary	30.74	25.34	18.80	13.21
Arkwin	12"	Rotary	28.10	28.15	23.94	20.30
Arkwin	3"	Sickle	31.37	26.03	16.41	14.00
Arkwin	6"	Rotary	31.41	27.86	21.21	19.68
Wintok	12"	Rotary	30.73	26.46	20.93	17.77
Wintok	3"	Rotary	29.37	25.86	18.69	16.86
Wintok	6"	Sickle	31.74	25.48	16.30	13.02
Bronco	12"	Sickle	32.64	27.59	20.08	11.60
Bronco	3"	Sickle	32.92	27.91	17.96	11.44
Bronco	6"	Sickle	33.22	27.77	19.74	11.41

TABLE VIII

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE FIRST REPLICATION OF THE NOVEMBER 4, 1958 HARVEST

Treatment	Composition - Percent				
	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	34.54	25.25	9.29	22.44	30.02
2	36.36	26.32	10.04	21.94	29.78
3	16.67	7.39	9.28	29.69	32.06
4	20.05	11.37	8.68	29.06	32.79
5	49.86	42.31	7.55	18.13	31.43
6	24.71	15.37	9.34	26.69	31.54
7	28.47	18.65	9.82	26.19	32.19
8	23.92	13.50	10.42	26.44	30.57
9	25.46	15.71	9.75	26.63	31.59
10	43.79	34.05	9.74	17.69	26.82
11	16.81	7.61	9.20	28.44	30.78
12	14.69	5.30	9.39	32.75	34.58
13	36.91	27.73	9.18	22.75	31.48
14	48.13	39.43	8.70	16.65	27.49
15	33.67	25.27	8.40	23.94	32.03
16	20.43	11.59	8.84	28.50	32.24
17	13.89	4.61	9.28	30.81	32.30
18	13.39	3.82	9.57	32.25	33.53

TABLE IX

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE SECOND REPLICATION OF THE NOVEMBER 4, 1958 HARVEST

Treatment	Composition - Percent				
	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	17.01	7.83	9.18	28.94	31.40
2	30.75	21.07	9.68	23.31	29.53
3	20.69	10.49	10.20	27.38	30.59
4	22.60	14.03	8.57	28.88	33.59
5	13.45	3.97	9.48	32.81	34.17
6	30.34	21.11	9.23	24.75	31.37
7	71.83	64.04	7.79	9.63	26.80
8	29.45	19.74	9.71	24.19	30.14
9	29.01	19.08	9.93	24.94	30.82
10	42.25	32.97	9.28	18.81	28.06
11	15.75	5.71	10.04	29.63	31.42
12	35.81	27.57	8.24	21.56	29.77
13	36.63	27.45	9.18	21.81	30.06
14	40.84	31.47	9.37	20.88	30.47
15	14.56	5.23	9.33	28.13	29.68
16	16.63	8.91	7.72	29.00	31.84
17	14.53	4.83	9.70	32.25	33.89
18	25.27	16.02	9.25	26.69	31.78

TABLE X

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE THIRD REPLICATION OF THE NOVEMBER 4, 1958 HARVEST

Treatment	Composition - Percent				
	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	22.29	12.96	9.33	25.00	28.72
2	26.29	12.91	13.38	24.13	27.71
3	23.35	13.99	9.36	26.69	31.03
4	14.11	5.11	9.00	32.19	33.92
5	14.41	5.40	9.01	32.88	34.76
6	28.11	17.46	10.65	31.13	37.71
7	35.26	24.53	10.73	29.31	38.84
8	21.07	9.99	11.08	28.88	32.09
9	23.15	12.15	11.00	26.19	29.81
10	35.72	25.01	10.71	22.06	29.41
11	18.52	8.13	10.39	29.31	31.90
12	40.71	32.01	8.70	20.31	29.87
13	29.06	18.05	11.01	25.13	30.66
14	24.39	13.60	10.79	26.06	30.16
15	14.01	4.67	9.34	31.94	33.50
16	17.69	7.85	9.84	31.19	33.84
17	16.49	6.55	9.94	30.44	32.57
18	14.37	4.65	9.72	32.75	34.34

TABLE XI

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE FIRST REPLICATION OF THE MARCH 31, 1959 HARVEST

Treatment	Composition - Percent				
	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	17.75	10.33	7.42	27.56	30.73
2	25.33	18.55	6.67	22.88	28.09
3	49.46	42.89	6.57	20.69	36.23
4	12.27	6.43	5.84	23.94	25.59
5	10.09	4.63	5.46	22.75	23.85
6	29.94	18.75	11.19	23.13	28.47
7	28.09	20.84	7.25	25.13	31.75
8	21.26	14.79	6.47	21.63	25.38
9	27.71	21.17	6.54	21.25	26.96
10	34.70	27.53	7.17	21.63	29.85
11	10.33	3.35	6.98	25.25	26.13
12	28.35	20.87	7.48	24.81	31.35
13	27.43	21.33	6.10	21.88	27.81
14	18.05	11.49	6.56	22.31	25.21
15	13.46	7.39	6.07	25.31	24.17
16	27.88	20.51	7.37	22.56	28.38
17	9.25	2.43	6.82	28.00	28.70
18	11.43	4.45	6.98	27.69	28.98

TABLE XII

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE SECOND REPLICATION OF THE MARCH 31, 1959 HARVEST

Treatment	Composition - Percent				
	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	12.25	5.58	6.67	24.69	26.15
2	15.71	8.57	7.14	24.44	26.73
3	15.07	8.45	6.62	25.56	27.92
4	10.57	3.91	6.67	25.56	26.59
5	8.07	2.45	5.62	23.16	23.74
6	16.55	10.44	6.11	25.94	28.96
7	18.90	10.93	7.97	23.88	26.81
8	22.65	15.35	7.30	24.75	29.24
9	14.14	7.63	6.51	23.25	25.17
10	30.65	23.68	6.97	23.16	30.35
11	10.01	2.95	7.06	26.25	27.05
12	17.70	11.09	6.61	21.19	23.83
13	16.61	10.16	6.45	22.19	24.70
14	16.72	9.78	6.94	24.00	26.60
15	8.92	2.77	6.15	25.88	26.62
16	15.77	8.23	7.54	26.06	28.40
17	12.01	5.37	6.64	27.00	28.53
18	9.80	2.31	7.49	29.56	30.26

TABLE XIII

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE THIRD REPLICATION OF THE MARCH 31, 1959 HARVEST

	Composition - Percent				
Treatment	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	27.85	20.79	7.06	19.13	24.15
2	14.89	8.31	6.58	20.75	22.63
3	16.28	9.89	6.39	24.81	27.53
4	11.97	5.69	6.28	21.81	23.13
5	10.79	4.43	6.36	22.00	23.02
6	19.05	12.73	6.32	20.31	23.27
7	15.10	7.99	7.11	24.44	26.56
8	16.03	9.74	6.29	22.69	25.14
9	16.35	9.17	7.18	21.69	23.88
10	17.45	11.31	6.14	21.50	24.24
11	11.25	4.69	6.56	23.75	24.92
12	20.01	13.69	6.32	24.50	28.39
13	20.27	13.46	6.81	23.25	26.87
14	12.59	6.61	5.98	24.06	25.76
15	15.07	9.24	5.83	22.38	24.66
16	19.91	13.63	6.28	22.44	25.98
17	10.26	4.03	6.23	25.44	26.51
18	18.18	12.51	5.67	21.06	24.07

TABLE XIV

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE FIRST REPLICATION OF THE APRIL 24, 1959 HARVEST

	Composition - Percent				
Treatment	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	8.57	1.75	6.82	21.13	21.51
2	21.99	15.46	6.53	16.44	19.45
3	8.95	2.41	6.54	16.50	16.91
4	7.29	2.35	4.94	13.81	14.14
5	6.77	1.83	4.94	17.69	18.02
6	17.79	10.88	6.91	24.06	27.00
7	15.48	7.04	8.44	25.81	27.76
8	11.59	5.78	5.81	17.56	18.64
9	27.89	21.57	6.32	15.25	19.44
10	22.53	15.07	7.46	21.31	25.09
11	7.09	1.55	5.54	14.69	14.92
12	29.37	21.27	8.10	17.94	22.79
13	35.56	28.79	6.77	16.25	22.82
14	13.45	7.12	6.33	18.81	20.25
15	7.64	2.99	4.65	15.94	16.43
16	9.43	3.19	6.24	19.38	20.02
17	8.07	2.07	6.00	18.31	18.70
18	8.90	2.62	6.28	19.25	19.77

TABLE XV

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE SECOND REPLICATION OF THE APRIL 24, 1959 HARVEST

Treatment	Composition - Percent				
	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	8.79	2.53	6.26	16.75	17.18
2	22.28	15.81	6.47	15.38	18.27
3	7.63	1.99	5.64	15.25	15.56
4	7.54	2.68	4.86	16.38	16.83
5	6.75	1.81	4.94	15.75	16.04
6	23.57	17.52	6.05	18.63	22.59
7	14.70	8.93	5.77	18.75	20.59
8	22.52	15.25	7.27	18.69	22.05
9	15.79	9.89	5.90	17.94	19.91
10	15.43	7.27	8.16	25.56	27.56
11	8.61	2.35	6.26	17.13	17.54
12	11.65	6.06	5.59	15.31	16.30
13	16.33	10.45	5.88	16.56	18.49
14	27.79	21.48	6.31	14.50	18.47
15	7.42	2.07	5.35	16.19	16.53
16	10.40	3.35	7.05	20.94	21.67
17	8.47	2.43	6.04	17.50	17.93
18	8.24	1.69	6.55	20.50	20.85

TABLE XVI

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE THIRD REPLICATION OF THE APRIL 24, 1959 HARVEST

	Composition - Percent				
Treatment	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	9.73	3.23	6.50	15.56	16.08
2	11.69	4.37	7.32	17.63	18.43
3	28.79	21.55	7.24	18.56	23.66
4	7.73	3.01	4.72	15.25	15.72
5	6.87	2.05	4.82	13.94	14.23
6	25.21	19.35	5.86	14.19	17.50
7	8.05	2.11	5.94	21.19	21.65
8	14.94	8.63	6.31	17.63	19.29
9	9.96	4.35	5.61	16.31	17.05
10	33.47	26.73	6.74	14.06	19.19
11	6.74	1.74	5.00	16.50	16.79
12	17.09	12.80	4.16	21.69	22.63
13	15.63	8.71	6.92	19.63	21.50
14	17.82	11.81	6.01	15.31	17.36
15	7.83	2.41	5.42	15.56	15.94
16	8.73	3.32	5.41	17.94	18.56
17	8.19	2.55	5.64	16.81	17.25
18	8.85	2.51	6.34	18.13	18.60

TABLE XVII

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE FIRST REPLICATION OF THE MAY 14, 1959 HARVEST

Treatment	Composition - Percent				
	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	9.25	1.53	7.72	16.81	17.07
2	15.51	9.39	6.12	13.19	14.56
3	8.87	3.47	5.40	14.25	14.76
4	8.01	3.59	4.42	11.75	12.19
5	6.18	2.39	3.79	14.19	14.54
6	20.33	13.05	7.28	18.56	21.35
7	14.77	7.44	7.33	19.13	20.67
8	14.51	8.43	6.08	12.88	14.07
9	12.91	6.60	6.31	10.63	11.38
10	27.31	18.75	7.56	19.31	23.77
11	8.22	2.65	5.57	13.31	13.67
12	25.31	18.63	6.68	17.75	21.81
13	22.85	16.13	6.72	16.69	19.90
14	13.93	7.58	6.35	16.50	17.85
15	7.69	3.51	4.18	14.25	14.77
16	6.08	2.41	3.67	10.44	10.70
17	8.43	3.08	5.35	9.63	10.17
18	8.11	2.55	5.56	10.31	10.58

TABLE XVIII

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE SECOND REPLICATION OF THE MAY 14, 1959 HARVEST

Treatment	Composition - Percent				
	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	8.75	3.46	5.29	13.44	13.92
2	19.81	13.63	6.18	17.00	19.68
3	9.05	3.71	5.34	14.38	14.93
4	6.78	2.20	4.58	12.69	12.97
5	6.79	2.53	4.26	12.50	12.82
6	17.44	10.49	6.95	15.88	17.74
7	21.69	14.53	7.16	13.69	16.01
8	14.59	7.93	6.66	14.44	15.68
9	14.37	7.95	6.42	13.63	14.81
10	16.62	8.51	8.11	18.44	20.15
11	8.83	2.93	5.90	15.44	15.91
12	18.90	12.35	6.55	13.94	15.90
13	19.59	12.57	7.02	14.75	16.87
14	18.98	12.46	6.52	15.63	17.85
15	8.89	2.68	6.21	11.69	12.01
16	8.29	3.21	5.08	11.94	12.33
17	7.38	2.74	4.64	12.94	13.30
18	9.53	2.83	6.70	12.50	12.86

TABLE XIX

CHEMICAL ANALYSES OF THE FORAGE YIELDS FROM THE THIRD REPLICATION OF THE MAY 14, 1959 HARVEST

	Composition - Percent				
Treatment	Ash	Insoluble Ash	Soluble Ash	Protein	Protein Insoluble Ash Free
1	12.09	5.03	7.06	15.81	16.65
2	14.99	8.49	6.50	16.13	17.63
3	7.42	2.81	4.61	13.25	13.63
4	7.96	2.99	4.97	11.44	11.79
5	7.97	3.31	4.66	12.00	12.41
6	14.94	8.63	6.31	12.81	14.02
7	19.01	11.17	7.84	14.38	16.19
8	14.60	7.64	6.96	13.50	14.62
9	15.91	9.31	6.60	12.19	13.44
10	24.81	17.31	7.50	14.06	17.00
11	7.84	2.38	5.46	12.13	12.43
12	14.97	6.46	8.51	19.94	21.32
13	20.13	13.47	6.66	14.31	16.54
14	12.54	6.43	6.11	13.94	14.90
15	7.39	2.75	4.64	11.94	12.28
16	9.21	2.99	6.22	11.44	11.79
17	9.07	3.23	5.84	10.50	10.85
18	7.55	2.72	4.83	10.50	10.79

TABLE XX

MULTIPLE RANGE TEST OF THE INSOLUBLE ASH CONTENT OF FORAGE FROM THE NOVEMBER 4, 1958 HARVEST

Treatment			Mean %	Multiple Range /x			
Bronco	12"	Rotary	35.74	|			
Arkwin	12"	Rotary	30.68	|	|		
Wintok	3"	Rotary	28.17	|	|	|	
Wintok	12"	Rotary	24.41	|	|	|	|
Arkwin	6"	Rotary	21.62	|	|	|	|
Arkwin	3"	Rotary	20.10	|	|	|	|
Wintok	6"	Rotary	17.98	|	|	|	|
Wintok	3"	Sickle	17.22	|	|	|	|
Bronco	6"	Rotary	15.65		|	|	|
Arkwin	12"	Sickle	15.35		|	|	|
Bronco	3"	Rotary	14.41		|	|	|
Wintok	6"	Sickle	11.72		|	|	|
Arkwin	6"	Sickle	10.62			|	|
Wintok	12"	Sickle	10.17			|	|
Bronco	12"	Sickle	9.45			|	|
Bronco	6"	Sickle	8.16				|
Arkwin	3"	Sickle	7.15				|
Bronco	3"	Sickle	5.33				|

/x Any two means underscored by the same line are not significantly different at the 5% level.

TABLE XXI

MULTIPLE RANGE TEST OF THE INSOLUBLE ASH CONTENT OF FORAGE FROM THE MARCH 31, 1959 HARVEST

Treatment			Mean %	Multiple Range /x			
Arkwin	12"	Rotary	20.84	|			
Arkwin	6"	Sickle	20.41	|	|		
Arkwin	6"	Rotary	15.22	|	|	|	
Wintok	12"	Rotary	14.98	|	|	|	|
Bronco	12"	Sickle	14.12	|	|	|	|
Wintok	6"	Rotary	13.97	|	|	|	|
Bronco	3"	Rotary	13.29	|	|	|	|
Bronco	12"	Rotary	13.25	|	|	|	|
Bronco	6"	Rotary	12.66	|	|	|	|
Arkwin	12"	Sickle	12.22	|	|	|	|
Arkwin	3"	Rotary	11.81	|	|	|	|
Wintok	3"	Rotary	9.29		|	|	|
Wintok	6"	Sickle	6.47			|	|
Bronco	6"	Sickle	6.42			|	|
Wintok	12"	Sickle	5.34			|	|
Bronco	3"	Sickle	3.94			|	|
Wintok	3"	Sickle	3.84			|	|
Arkwin	3"	Sickle	3.66				|

/x Any two means underscored by the same line are not significantly different at the 5% level.

TABLE XXII

MULTIPLE RANGE TEST OF THE INSOLUBLE ASH CONTENT OF FORAGE FROM THE APRIL 24, 1959 HARVEST

Treatment			Mean %	Multiple Range /x
Arkwin	12"	Rotary	16.36	│
Wintok	12"	Rotary	15.98	│
Wintok	6"	Rotary	15.92	│
Wintok	3"	Rotary	13.47	│ │
Arkwin	6"	Rotary	13.38	│ │
Bronco	6"	Rotary	11.94	│ │
Arkwin	3"	Rotary	11.88	│ │
Bronco	3"	Rotary	9.89	│ │
Arkwin	6"	Sickle	8.65	│ │
Bronco	12"	Rotary	6.02	│ │
Bronco	12"	Sickle	3.29	│
Wintok	12"	Sickle	2.68	│
Arkwin	12"	Sickle	2.52	│
Wintok	6"	Sickle	2.49	│
Bronco	3"	Sickle	2.35	│
Bronco	6"	Sickle	2.27	│
Wintok	3"	Sickle	1.90	│
Arkwin	3"	Sickle	1.88	│

/x Any two means underscored by the same line are not significantly different at the 5% level.

As in all previous harvests, the rotary clipped samples from the May 14 clipping contained the largest amount of insoluble ash. Samples from the 12-inch spacing had the highest percentages (Table XXIII and Appendix Table IX).

The rotary clipped samples were highest in insoluble ash in all cuttings. All samples had higher percentages in the fall than in the spring. In two of the harvests percentages increased as row spacing increased. Data from one harvest showed that samples of Arkwin, which has an upright type of growth habit, contained the most insoluble ash. The suction caused by the whirling blade of the rotary mower is probably the cause of the larger amount of insoluble ash in the rotary clipped samples. The succulent condition of the young forage, which might cause more soil particles to adhere to the leaves in the harvesting process, may be the reason for the higher percentages in the fall. The statistical analyses of the data appear to indicate that as the area of bare soil surface increases the amount of insoluble ash picked up by the rotary mower also increases. This is perhaps the reason for the large amount of forage obtained by the rotary mower in the 12-inch spacing. Under this theory if a rotary mower is to be used the minimum insoluble ash would be picked up by using a variety with prostrate type of growth habit sown in narrow row spacings.

The high insoluble ash content of samples is of considerable importance to the chemist. As the insoluble ash content increases it becomes more difficult to obtain an accurate chemical analysis.

TABLE XXIII

MULTIPLE RANGE TEST OF THE INSOLUBLE ASH CONTENT OF FORAGE FROM THE MAY 14, 1959 HARVEST

Treatment			Mean %	Multiple Range /x
Arkwin	12"	Rotary	14.86	
Wintok	12"	Rotary	14.06	
Arkwin	6"	Rotary	12.48	
Bronco	12"	Rotary	11.05	
Wintok	6"	Rotary	10.72	
Arkwin	3"	Rotary	10.50	
Wintok	3"	Rotary	8.82	
Bronco	3"	Rotary	8.00	
Bronco	6"	Rotary	7.95	
Arkwin	12"	Sickle	3.34	
Arkwin	6"	Sickle	3.33	
Bronco	3"	Sickle	3.02	
Wintok	6"	Sickle	2.98	
Wintok	12"	Sickle	2.93	
Bronco	12"	Sickle	2.87	
Wintok	3"	Sickle	2.74	
Bronco	6"	Sickle	2.70	
Arkwin	3"	Sickle	2.65	

/x Any two means underscored by the same line are not significantly different at the 5% level.

There also arises a question concerning the determination of forage yields. It appears difficult to report accurate forage yields when the insoluble ash content of those samples harvested with the rotary mower is as high and variable as in this study.

These results seem to indicate that the use of the sickle mower in further experimental work would give more accurate results in both chemical analyses and forage yield determinations than could be obtained with the rotary mower.

SUMMARY AND CONCLUSIONS

A study to determine the effect of row spacing and type of mower on forage yields of three varieties of winter oats was conducted at the Agronomy Research Station, Stillwater, Oklahoma in 1958-1959 on a Kirkland silt loam soil.

Three varieties of winter oats (Arkwin, Bronco and Wintok) representing upright, intermediate and prostrate type of growth habit, respectively, were seeded at an equivalent rate based on pure live seed in three row spacings (3, 6 and 12 inches). Two types of mowers (rotary and sickle) were used to harvest the forage.

The field layout consisted of a randomized block design with three replications. Each plot was three feet wide and twenty feet long.

Rainfall was supplemented with sprinkler irrigation as needed to prevent moisture from becoming a limiting factor in forage yield.

The rotary mower obtained the most forage early in the season while the plots harvested with the sickle mower yielded more in the late season. Those samples harvested with the rotary mower contained a higher insoluble ash content than those harvested with the sickle mower. As the area of bare soil surface increased, the insoluble ash content of those samples harvested with the rotary mower appeared to increase.

Arkwin was a high forage producer at all three spacings in the fall. Bronco was the outstanding variety in late spring. In total production Bronco was a high producer at all three spacings. All three varieties used were high in total forage production when seeded in 3-inch row spacing and harvested with the sickle mower.

The results of this study indicate that Arkwin is the best of the three varieties used if maximum production is desired in the fall. Bronco is by far the best variety of those tested for late spring production. Considering all three varieties used, the 3-inch row spacing harvested with the sickle mower would be optimum for total forage production under the conditions existing in this study. It appears that the sickle mower will give more accurate results than the rotary mower both in chemical analyses and forage yield determinations.

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APPENDIX

APPENDIX TABLE I

ANALYSIS OF VARIANCE OF THE FORAGE YIELDS FROM THE NOVEMBER 4, 1958 HARVEST

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Total	53	49,273		
Replications	2	70		
Treatments	17	33,539	1,973	4.28**
Mower	1	18,853	18,853	40.90**
Spacing	2	3,929	1,965	4.26*
Variety	2	4,434	2,217	4.81*
M X S	2	5,014	2,507	5.44**
M X V	2	557	279	
S X V	4	449	112	
M X S X V	4	303	76	
Error	34	15,664	461	

* Indicates significance at the 5% level.

** Indicates significance at the 1% level.

APPENDIX TABLE II

ANALYSIS OF VARIANCE OF THE FORAGE YIELDS
FROM THE MARCH 31, 1959 HARVEST

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Total	53	101,951		
Replications	2	10,590		
Treatments	17	62,813	3,695	4.40**
Mower	1	29,728	29,728	35.39**
Spacing	2	19,335	9,668	11.51**
Variety	2	1,032	516	
M X S	2	523	262	
M X V	2	1,491	746	
S X V	4	6,195	1,549	
M X S X V	4	4,509	1,127	
Error	34	28,548	840	

** Indicates significance at the 1% level.

APPENDIX TABLE III

ANALYSIS OF VARIANCE OF THE FORAGE YIELDS
FROM THE APRIL 24, 1959 HARVEST

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Total	53	512,172		
Replications	2	105,618		
Treatments	17	230,994	13,588	2.63**
Mower	1	124,993	124,993	24.20**
Spacing	2	12,601	6,300	
Variety	2	19,827	9,914	
M X S	2	47,836	23,918	4.63*
M X V	2	4,284	2,142	
S X V	4	12,939	3,235	
M X S X V	4	27,506	6,877	
Error	34	175,560	5,164	

* Indicates significance at the 5% level.

** Indicates significance at the 1% level.

APPENDIX TABLE IV

ANALYSIS OF VARIANCE OF THE FORAGE YIELDS FROM THE MAY 14, 1959 HARVEST

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Total	53	507,866		
Replications	2	5,967		
Treatments	17	425,308	25,018	11.10**
Mower	1	74,519	74,519	33.08**
Spacing	2	7,709	3,855	
Variety	2	271,660	135,830	60.29**
M X S	2	17,835	8,918	3.96*
M X V	2	38,813	19,407	8.61**
S X V	4	13,615	3,404	
M X S X V	4	1,157	289	
Error	34	76,591	2,253	

* Indicates significance at the 5% level.

** Indicates significance at the 1% level.

APPENDIX TABLE V

ANALYSIS OF VARIANCE OF THE TOTAL ACCUMULATED FORAGE YIELDS

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Total	53	1,202,616		
Replications	2	256,316		
Treatments	17	589,733	34,690	3.31**
Mower	1	100,363	100,363	9.57**
Spacing	2	107,856	53,928	5.14*
Variety	2	158,515	79,258	7.56**
M X S	2	154,982	77,491	7.39**
M X V	2	8,745	4,373	
S X V	4	26,118	6,530	
M X S X V	4	33,154	8,289	
Error	34	356,567	10,487	

* Indicates significance at the 5% level.

** Indicates significance at the 1% level.

APPENDIX TABLE VI

ANALYSIS OF VARIANCE OF THE INSOLUBLE ASH CONTENT OF FORAGE FROM THE NOVEMBER 4, 1958 HARVEST

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Total	53	7,551.92		
Replications	2	396.91		
Treatment	17	3,733.08	219.59	2.18*
Mower	1	2,149.81	2,149.81	21.36**
Spacing	2	460.40	230.20	
Variety	2	122.87	61.43	
M X S	2	259.97	129.98	
M X V	2	34.10	17.05	
S X V	4	577.29	144.32	
M X S X V	4	128.59	32.14	
Error	34	3,421.92	100.64	

* Indicates significance at the 5% level.

** Indicates significance at the 1% level.

APPENDIX TABLE VII

ANALYSIS OF VARIANCE OF THE INSOLUBLE ASH CONTENT OF FORAGE FROM THE MARCH 31, 1959 HARVEST

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Total	53	3,096.32		
Replications	2	503.09		
Treatment	17	1,450.29	85.31	2.53*
Mower	1	398.15	398.15	11.84**
Spacing	2	351.85	175.92	5.23*
Variety	2	238.68	119.34	3.55*
M X S	2	52.77	26.38	
M X V	2	32.35	16.17	
S X V	4	149.50	37.37	
M X S X V	4	226.97	56.74	
Error	34	1,142.92	33.61	

* Indicates significance at the 5% level.

** Indicates significance at the 1% level.

APPENDIX TABLE VIII

ANALYSIS OF VARIANCE OF THE INSOLUBLE ASH CONTENT OF FORAGE FROM THE APRIL 24, 1959 HARVEST

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Total	53	2,897.51		
Replications	2	11.57		
Treatment	17	1,631.37	95.96	2.60**
Mower	1	1,255.99	1,255.99	34.03**
Spacing	2	44.53	22.26	
Variety	2	106.71	53.35	
M X S	2	1.09	.54	
M X V	2	84.40	42.20	
S X V	4	35.97	8.99	
M X S X V	4	102.66	25.66	
Error	34	1,254.56	36.89	

** Indicates significance at the 1% level.

APPENDIX TABLE IX

ANALYSIS OF VARIANCE OF THE INSOLUBLE ASH CONTENT OF FORAGE FROM THE MAY 14, 1959 HARVEST

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Total	53	1,237.94		
Replications	2	5.73		
Treatment	17	1,011.86	59.52	9.18**
Mower	1	861.20	861.20	132.88**
Space	2	46.29	23.14	3.57*
Variety	2	33.76	16.88	
M X S	2	37.93	18.96	
M X V	2	26.25	13.12	
S X V	4	4.70	1.17	
M X S X V	4	1.71	.42	
Error	34	220.34	6.48	

* Indicates significance at the 5% level.

** Indicates significance at the 1% level.

VITA

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