RELATIVE HAY YIELDING ABILITY OF TEN VARIETIES OF WINTER OATS AND ANALYSIS OF PLANT CHARACTERISTICS WHICH AFFECT YIELD AND QUALITY OF OAT HAY

by

DENNIS PEIER

Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1958

Submitted to the Faculty of the Graduate School of
the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
August, 1960

RELATIVE HAY YIELDING ABILITY OF TEN VARIETIES OF WINTER OATS AND ANALYSIS OF PLANT CHARACTERISTICS WHICH AFFECT YIELD AND QUALITY OF OAT HAY

Thesis Approved:

Boyd G. Curtis
Thesis Adviser

Lester V. Reed

Glenn E. Todd

Dale E. Weibel

Dean of the Graduate School

ACKNOWLEDGMENTS

The author would like to express deepest appreciation to his major advisor, Dr. Byrd C. Curtis, for counsel and guidance throughout the program of study. Further, thanks is due for suggestions and criticism offered during the preparation of the manuscript.

The author wishes to thank Dr. A. M. Schlehuber for advice during the early part of the program of study.

The author is most grateful to Drs. D. E. Weibel, L. W. Reed and G. W. Todd for offering advice during the period of study and reading the manuscript during preparation.

Sincere thanks is due Dr. R. D. Morrison of the Statistics Department for his time and advice in compiling and analyzing data used in the study.

Assistance received from members of the Small Grains Section of the Agronomy Department is deeply appreciated.

To Oklahoma State University, the author is especially grateful for the research assistantship and funds made available for the electronic statistical analysis.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

A need for greater production of hay has arisen in Oklahoma during the past several years due to the increased number of livestock, especially cattle and calves. A greater amount of roughage is needed for overwintering livestock particularly when winter pasture is scarce.

The production of the major sources of hay, alfalfa and native grass are somewhat inconsistent due to drouth and insect problems which often occur in Oklahoma. Winter oats appear to be the most productive and palatable of the cereals and seem to offer an excellent source of high quality hay which could be produced rather consistently from year to year.

A distinct advantage of winter oats is that winter pasture may be produced and then later a hay crop harvested. If the hay is not needed, a grain crop may be harvested.

Little information is available at the present time concerning hay production of the different varieties of oats adapted to Oklahoma. This type of information is needed to initiate a breeding program to develop hay type oats and to make recommendations as to the hay yielding ability of presently available varieties. Hay quality information regarding the percentage of leaves, stems and heads contributed by each variety is also needed.

The grain producing ability of different oat varieties is also of importance in addition to hay yielding capacity. A dual purpose variety which produces high yields of grain as well as high yields of hay would

be desirable. No information is available concerning the compatability of grain and hay yield.

The objectives of the study are as follows:

(1) Determine which existing varieties or strains of oats adapted to Oklahoma will produce the greatest yields of hay.

(2) Determine the quality of the hay by utilizing the relationship of 3 plant components (heads, leaves and stems).

(3) Determine if any of the varieties or strains tested were suitable for a dual purpose role, i.e., production of high yields of grain as well as high yields of hay.

REVIEW OF LITERATURE

A review of literature reveals that relatively little work has been done regarding the effect of plant components on yield and quality of oat hay. However, a great deal of work has been done regarding feeding value, proper stage of maturity for harvest, cultural methods and plant characteristics (tillering ability, height and maturity) with regards to yield and quality of oat hay. This work will be considered in addition to that with plant components.

It is important to consider what is contributed by the various components of the plant. Bartlett (3)[1/] cut oats at 3 levels from the ground and found that the bottom section had very little nutrient value. The second section had about half as much protein as the top section and its digestibility was considered to be less. He advised leaving a high stubble 8 to 10 inches high and stated that the loss incurred by leaving the coarser part of the stalks on the ground would be compensated by the improved quality and palatability of the hay.

Hendry and Woll (9) tested 3 oat varieties and 1 species of wild oats (Avena barbata) in production trials. They found that among the different oats tested, California Red, which was one of the best grain producers in the locality, exceeded all other varieties by having 32% of its weight in heads while in the soft dough. Coastblack and Roberts oats,

---

[1/] Figures in parenthesis refer to "Literature Cited" page 40.

which were late in maturity and poorly adapted to the area for grain production, yielded only 22% and 21% of heads respectively by weight. The wild oat produced grain freely but because of its deciduous seed habit, was found to consist of only 26% heads by weight in the soft dough.

Stotola (22) stated that the ratio of stem, leaf and head in a cereal plant affects both its nutritive value and its chemical composition. His data showed that the physical composition (stem-leaf-head ratio) is a fairly reliable and practical index of feeding value. Also, he found a regular decline in the percentage leafiness as the plant matured although the actual weight of leaves did not necessarily change.

Thompson and Day (24) compared 4 varieties of oats for hay production in Arizona. The variety, Markton, was found to be the best producer of the four. They stated that one reason why farmers like Markton oats for hay production is because it had a high ratio of leaves to stems.

The nutritive value and palatability of oat hay has long been recognized. According to Thatcher (23), an acre of oats will furnish about the same quantity of nutrients either as hay or as grain. Morrison (15) stated that well-cured hay from the small grains resembles good timothy hay in composition and feeding value and that it may be used similarly.

Guilbert (8) found that wild oat hay and rolled barley, when fed with sufficient cottonseed meal to supply protein, were almost equal to alfalfa hay and rolled barley in weight gain and finish on yearling steers.

From experiments concerning oats and other cereal hays, Hendry and Woll (9) reported that in general, oats, because of soft texture, is regarded as the most palatable of cereal hays. Oats was found to contain the highest percentage of leaves and a moderate amount of grain and stalk.

Stanton and Coffman (21) stated that fall-sown oats furnish excellent winter grazing and hay for nearly all classes of farm animals. Fall-sown oats may supply considerable grazing during the late fall and then later be harvested for hay or grain. Much lodging may occur when the crop is sown on fertile soils and not pastured. They concluded that grazing is both beneficial and profitable under such conditions.

Justus and Thurman (11) conducted experiments to determine the effect of clipping and grazing on the subsequent growth of winter oats. The unclipped plots produced significantly greater air-dry hay yields per acre than did the clipped plots. However, forage removed by grazing should more than compensate for the loss incurred by this practice.

Much experimental work has been done concerning the stage of maturity which will yield the greatest amount of high quality hay. As early as 1901, Barlett (3) presented analyses of oat hays cut at different stages of growth. Results of these experiments indicated that the nutrients of oat hay are in the most digestible form when the heads are in the milk stage of maturity. When the plants were cut while in the bloom stage, there was less yield of poorer composition and digestibility than if cut in the milk stage. When cutting was delayed until the oats were in the dough stage, the slightly larger yield was reported to be offset by the lower quality and lessened digestibility of the hay. Keith and Tarbox (12) stated that if a nitrogenous forage is desired, cutting should be done in the early milk stage when the whole plant is quite palatable. However, if a forage high in carbohydrates is desired, cutting at the beginning of the dough stage is necessary. After this time they found a continued increase of starch in the seed, but the other parts of the

plant were decreasing rapidly in feed value.

Hendry and Woll (9) reported that the stage of maturity when cut affects the yield, palatability and the chemical and physical composition of cereal hays. Greatest production of oat hay was found at the soft dough stage of maturity.

Stotola (22) analyzed oats along with other cereal plants at different stages of maturity. He concluded that any benefits resulting from increased digestibility past the medium dough stage would seem to be more than offset by shattering of the kernels, leaf loss, leaching and a general deterioration of the plant structure.

A number of more recent workers (1, 13, 14, 15, 16, 21, 25) have given consideration to the proper stage of maturity for harvest of oat hay. In general, they all accept the soft dough stage or sometime during the dough stage as the proper time to harvest oats for the greatest yields and yet maintain quality in the hay.

The yielding capacity inherent to different varieties of oats is of upmost importance from an economic standpoint. Ahlegren (1) stated that wide differences exist in the yielding ability of the many varieties of oats so that studies of this characteristic are important in evaluating them for hay production.

Other factors that have been reported to affect yield and quality of hay are tillering ability, maturity, plant height and the rate of seeding. Frey and Wiggans (7) reported that oat varieties have tillering capacities which are relatively constant from year to year and that most winter oat varieties produce many tillers. They expressed an opinion that one of the characteristics which may become important in the production of better

oat varieties is the inherent tillering capacity.

Thurman et al. (25) recommended planting spring-sown oats at a higher rate per acre than fall oats because of a much lower tillering rate under Arkansas conditions. In 1954, they obtained higher hay yields from winter oats at low rates of seeding than from high rates. However, the higher yields were due to larger stems which they considered undesirable. Plants from the high rates of sowing were significantly taller than those from the lower rates. In clipping experiments, Justus and Thurman (11) found no significant difference at the soft dough stage between height of plants in clipped and unclipped plots. They found that plant height increased directly with an increased sowing rate and inversely with increased row spacing. A delayed maturity of 3 to 5 days was found following clipping and 4 to 8 days following grazing.

According to Thatcher (23), late and medium maturing varieties of oats yield more hay per acre than the early varieties. Their data showed that the early varieties yield about 90% as much hay as later varieties.

The inherent grain producing ability is another important characteristic which should be considered in a variety of oats to be used for hay production.

Thurman et al. (25) expressed the opinion that a high grain-producing variety is preferable when sowing oats for hay so that if the hay is not needed the crop can be harvested for the grain.

MATERIALS AND METHODS

Experimental Materials

Ten varieties of winter oats were selected to obtain information relative to hay yielding ability. Nine of the varieties were selected on the basis of their appearance as "tall, leafy types" in tests of previous years. One variety, Cimarron, was included for the purpose of checking the relative hay yielding capacity of a short-strawed, heavy tillering type in contrast to the tall, leafy type.

Arkwin (C.I.[1/] 5850) is a variety developed by workers at the Arkansas Agricultural Experiment Station. According to Rosen et al. (17), Arkwin represents a selection from a cross of Tennessee 1922 X Bond-Iogold. Early growth of Arkwin is relatively rapid and the seedling growth habit is upright or intermediate. The stems are relatively thick and strong. It is felt that Arkwin is one of the few varieties that combines an upright seedling growth habit with winterhardiness. Yields of grain from this variety are reported to be high in Arkansas; however, after extensive testing in Oklahoma, Arkwin is rated as only a fair yielding type. This variety appears to combine one of the widest ranges of disease resistance now known in a variety of oats.

Coffman et al. (5) report that Arlington (C.I. 4657) and Atlantic (C.I. 4599) are both selections from an experimental strain designated as

---

[1/] Accession number of the Division of Cereal Crops and Diseases, U.S. Department of Agriculture.

C.I. 4316. This strain resulted from an F_4 selection from a Lee-Victoria X Fulwin cross. Both varieties are described as being similar in plant and kernel characteristics. Both tiller vigorously and are early maturing, tall growing, and reasonably stiff-strawed, productive oats. Arlington is more upright in early growth and is less winterhardy than Atlantic. Lack of winterhardiness is a limiting factor for adaptation to Oklahoma conditions. Both varieties are reported to have resistance to ordinary races of crown rust /Puccinia coronata (Pers.) Cda./ and to oat mosaic (Marmor spp.).

Bronco (C.I. 6571) was developed by the Texas Agricultural Experiment Station from a cross of Lee-Victoria X Fulwin (2). In regional trials throughout the southern states, Bronco has produced one of the most outstanding grain yield records of any oat variety yet developed. Bronco is described as having a very prostrate growth habit in the seedling stage and is noted for its lack of winter forage production. It is tall with large, strong straw under most conditions and is late maturing. It is susceptible to some races of leaf rust and is very susceptible to stem rust (Puccinia graminis avenae Eriks. and Henn.). Bronco is listed as a recommended variety in Oklahoma.

Cimarron (C.I. 5106) originated from a mass selection of early maturing panicles from Woodward Winter Oat Composite (C.I. 3527) in the spring of 1946 (18). Cimarron is an extremely early, short strawed, winterhardy type, with wide, light-green leaves. It has been an excellent grain yielder under Oklahoma conditions. It is resistant to Victoria blight (Helminthosporium victoriae Meehan and Murphy) and soil borne mosaic. It is susceptible to rusts and smuts (Ustilago spp.) and to a physiological foliar disease, designated as "Cimarron Blight", which may occur under humid con-

ditions. This disease or condition causes large, dried areas on the foliage during the jointing and heading stage. Cimarron is a recommended variety for northern and western Oklahoma.

Colo X Wintok (C.I. 5118) is an experimental strain received from Mr. F. A. Coffman[2] in 1957, for testing as a possible hay variety. It is tall, medium maturing and is characterized by many small culms and fine leaves. It appears to be quite winterhardy. This strain is resistant to Victoria blight and susceptible to most of the prevalent races of crown rust in Oklahoma.

Forkedeer (C.I. 3170) is a medium maturing selection of Winter Fulghum (4). It has fair straw strength, moderate winterhardiness and is very uniform in appearance. It is resistant to Victoria blight but susceptible to the rusts and smuts. It is recommended for sections of northern Oklahoma and will produce high yields of good quality grain under favorable conditions.

Stw. 553452[3] is a selection from a cross Forkedeer X [(Haj.-Joan. X Bond-Rainbow) X Santa Fe]. It is being tested for adaptation in Oklahoma. This strain is tall with wide leaves and thick stems. The seedling growth habit is similar to Forkedeer. This strain was resistant to prevalent races of crown rust at the beginning of this study but has apparently lost the resistance due to a change in the race picture.

Nysel (C.I. 5364) resulted from a single plant discovered in 1944, which showed unusual winterhardiness (10). It is a tall, weak-strawed,

---

[2] Senior Agronomist, Division of Cereal Crops and Diseases, U.S. Department of Agriculture.

[3] Stillwater Selection Number.

heavily tillered and late maturing variety under Oklahoma conditions. The seedling growth habit is predominantly decumbent. It is reported to have good winterhardiness. This variety is susceptible to prevalent races of crown rust in Oklahoma.

Stanton Strain 1 Selection (C.I. 6902) is a selection from Stanton Strain 1 (C.I. 3855). This strain is quite different from the parent variety which is described by Stanton (20). Stanton Strain 1 Selection is relatively tall, tillers well, and is very leafy. It has been early maturing under Oklahoma conditions. This strain is susceptible to Victoria blight and prevalent races of crown rust in Oklahoma. It has consistently produced grain of a low test weight which is undesirable for grain production.

Experimental Methods

This study was conducted for 3 consecutive crop years, 1958-1960, at the Agronomy Farm near Stillwater, Oklahoma. The 3 growing seasons differed somewhat thus expressing 3 different environments. The varieties were sown in a complete randomized block including 3 replications. Plot size was six 10-foot rows spaced 12 inches apart. The nursery was sown September 23, September 25 and October 12, respectively, for the 3-year test period. Emergence was complete within a range of 6 to 10 days for the 3 years.

Growth habit and percentage of winter survival were determined before growth resumed in late February or early March. Growth habit was determined by rating the varieties as upright, intermediate or decumbent. Winter survival is given as the percentage of plants surviving the winter.

Maturity (heading date) was recorded when each plot was at least 75% headed. This was recorded as the number of days from April 1 to facilitate statistical analysis. Tiller counts were made by counting the number of head-bearing tillers in two 1-foot sections in rows 1 and 6 for each plot. The average of the 4 counts gave an estimate of the average number of tillers per square foot.

Hay yields were obtained by harvesting a total of 16 feet from rows 3 and 4 of each plot when the varieties reached the soft dough stage of maturity. Maturity was determined by checking the central portion of the panicles. All harvests for hay were made between the hours 11:00 and 12:00 a.m. on the day harvested. After recording green weights, a 1000 gram sample was taken from each plot and dried at 140° F. for 48 hours. Dry matter per plot was computed by multiplying the percentage of dry matter by the total green weight per plot.

At 1:00 p.m. of the same day a 600 gram sample of each variety was harvested at ground level from four random locations in rows 1 and 6. Leaves, stems and panicles were separated in this sample. The leaves were removed at the ligule, the panicles were separated at the apex of the peduncle and the remaining stems were cut up in 3 and 4 inch sections to facilitate handling. Each component was weighed and placed in a small cotton sack to be dried as above. The percentage of dry matter contributed by each component was obtained by dividing the dry weight of the component by the total dry weight of all components. This percentage multiplied by the total dry weight per plot gave the yield for each component per plot.

Height was expressed in inches from the ground level to the top of the mass of panicles. Three random readings were made per plot and aver-

aged for the height per plot.

Rows 2 and 5 were harvested (16 feet) from each plot to determine yield of grain. The material was threshed with a Vogel threshing machine. The grain per plot was weighed to the nearest gram.

Statistical analyses were conducted on 8 of the observations as follows:

1. Hay yield (dry matter)
2. Grain yield
3. Hay yield components (dry matter)
    a. Leaves
    b. Stems
    c. Heads
4. Number of tillers
5. Maturity
6. Height

The statistical analyses were computed on an IBM Type 650 Magnetic Drum Data Processing Machine. Significance among the means of data were determined by the method described by Snedecor (19). Multiple range tests used were those proposed by Duncan (6).

RESULTS

Hay Yields and Yields of Hay Components - Dry Matter

Total Yield

The average total yields of dry matter per variety for the 3 crop years 1958-60 are presented in Table 1. Table 2 shows that a highly significant difference was found in the yield of total dry matter among the 3 years and also among the varieties. This situation was amplified by a highly significant year and variety interaction. The 5 highest yielding varieties were not significantly different at the 5% level of confidence. Since the yields of Forkedeer, Stanton Str. 1 Sel. and Bronco are within a range of 7 grams, they should perhaps be considered as equals. Although Arkwin and Stw. 553452 were not significantly different than these 3 varieties, they did yield considerably less. Cimarron, which was included to check the relative hay yielding capacity of a short-strawed and early-maturing variety, was lowest in yield of dry matter, being significantly lower than the other 9 varieties. Arlington, which possesses the next lowest mean, was severely reduced in stand (51% survival) by low temperatures during the winter of 1959-60.

Yield of Leaves

The percentage of the total dry weight contributed by each component for each variety is presented in Table 3. It is quite apparent that the percentage of leaves varied widely during the 3 years of the test. This indicates a year and variety interaction, which was found to be highly

Table 1. Average yield of dry matter for 10 winter oat varieties on a gram/plot basis for the years 1958-1960.

Year	Cimarron	Arlington	Nysel	Colo X Wintok	Atlantic	Stw. 553452	Arkwin	Bronco	Stn. Str. 1 Sel.	Forkedeer
1958	1250.33	1694.33	1536.00	1353.00	1614.00	1639.67	1658.67	1694.33	1694.33	1629.33
1959	1067.67	1361.00	1188.67	1426.00	1312.33	1309.00	1492.33	1395.67	1488.67	1496.67
1960	1146.00	956.33*	1321.33	1304.00	1169.00	1253.00	1211.67	1331.33	1248.33	1316.33
					Multiple Range (.05 level)					
Mean	1154.67	1337.22	1348.67	1361.00	1365.11	1400.56	1454.22	1473.78	1477.11	1480.78

Means underlined by a common line are not significantly different.

*51% stand due to winterkilling.

Table 2. A summary of statistical significance for characters analyzed for 10 winter oat varieties during the years 1958-1960.

Source of Variation	Hay Yield (Dry Matter)	Grain Yield	Hay Yield Components Dry Matter			Number of Tillers	Maturity	Height
			Leaves	Stems	Heads			
Year	**	**	**	**	**	**	**	**
Variety	**	**	**	**	**	**	**	**
Interaction (Year X Variety)	**	**	**	--	**	**	**	**

** Significant at the .01 level.
-- No significant difference.

Table 3. Percentage of the total dry weight contributed by each of the plant components for 10 winter oat varieties studied for the years 1958-1960.

	1958			1959			1960			Av.		
	Lvs.*	Stm.	Hd.	Lvs.	Stm.	Hd.	Lvs.	Stm.	Hd.	Lvs.	Stm.	Hd.
Arkwin	16.9	50.1	33.0	18.7	44.3	37.0	13.4	51.5	35.1	16.3	48.6	35.1
Arlington	15.2	43.6	41.2	22.2	40.5	37.3	10.7	45.2	44.1	16.0	43.1	40.9
Atlantic	14.6	44.1	41.3	20.2	41.4	38.4	13.2	48.6	38.2	16.0	44.7	39.3
Bronco	12.8	45.0	42.2	27.9	38.5	33.6	13.9	41.4	44.7	18.2	41.6	40.2
Cimarron	15.6	45.0	39.4	15.5	34.8	49.7	12.6	39.8	47.6	14.6	39.9	45.5
Colo X Wintok	18.5	43.3	38.2	20.6	43.6	35.8	12.1	45.5	42.4	17.1	44.1	38.8
Forkedeer	19.1	44.4	36.5	23.2	40.3	36.5	15.9	44.0	40.1	19.4	42.9	37.7
Stw. 553452	17.4	44.2	38.4	26.5	45.9	27.6	12.8	47.1	40.1	18.9	45.7	35.4
Nysel	15.5	48.3	36.2	26.8	41.1	32.1	14.3	42.0	43.7	18.9	43.8	37.3
Stanton Str. 1 Sel.	13.9	44.9	41.2	21.6	37.8	40.6	12.8	42.9	44.3	16.1	41.9	42.0

*Lvs. = Leaves, Stm. = Stems, Hd. = Heads.

significant. The most typical figures are the averages for the 3 years. Forkedeer possessed the highest percentage (19.4) of leaves on the average and was highest 2 of the 3 crop years.

The average dry weights of leaves produced by each variety for the 3 crop years are found in Table 4. As could be expected from the data already presented, Forkedeer yielded the greatest amount of leaves; however, it was not significantly higher than Stw. 553452 and Bronco. Stw. 553452 is a Forkedeer derivative and possesses the same characteristic leafiness as Forkedeer. Table 3 shows that Stw. 553452 on the average had 18.9% of its dry weight in leaves, exceeded only by Forkedeer and equal to Nysel. Bronco produced only 0.77 grams less leaves than Stw. 553452 in total dry weight and had 18.2% of its dry weight in leaves. Cimarron was significantly lower in dry weight of leaves than the other 9 varieties. This would be expected considering that on the average only 14.6% of its total dry weight was in leaves.

Yield of Stems

Average dry weights of stems per plot are shown in Table 5. Arkwin produced a significantly greater amount of dry weight in the stems than the other 9 varieties. Table 3 shows that Arkwin is consistently high in the percentage of dry weight for stems. Cimarron possessed a significantly lower amount of stems than the other varieties. The varieties other than Arkwin and Cimarron are within a relatively close range as indicated by the multiple range test. This again is quite apparent in Table 3 where the only extremes for percentage dry weight in stems are Arkwin and Cimarron. Considering a high percentage of stems to be undesirable in a variety for hay use, Arkwin is the only variety that appears

Table 4. Average dry weight of leaves for 10 winter oat varieties on a gram/plot basis for the years 1958-1960.

Year	Cimarron	Atlantic	Arlington	Stn. Str. 1 Sel.	Arkwin	Nysel	Colo X Wintok	Bronco	Stw. 553452	Forkedeer
1958	194.67	237.33	258.33	235.33	279.33	235.00	305.00	218.00	284.33	310.67
1959	163.67	267.33	301.00	321.00	279.00	317.67	294.67	388.33	345.33	349.67
1960	146.00	154.33	103.33*	159.67	162.67	189.67	157.67	183.33	162.00	210.00
					Multiple Range (.05 level)					
Mean	168.11	219.67	220.89	238.67	240.33	247.44	252.44	263.22	263.89	290.11

Means underlined by a common line are not significantly different.

*51% stand due to winterkilling.

Table 5. Average dry weight of stems for 10 winter oat varieties on a gram/plot basis for the years 1958-1960.

Year	Cimarron	Arlington	Nysel	Atlantic	Bronco	Stn. Str. 1 Sel.	Forkedeer	Stw. 553452	Colo X Wintok	Arkwin
1958	563.00	737.67	740.33	710.67	762.33	762.00	723.00	726.00	719.00	830.00
1959	364.33	551.00	490.00	543.00	537.67	563.33	604.33	602.00	622.33	660.33
1960	456.00	432.00*	555.33	568.67	552.00	537.00	578.67	588.67	593.00	623.67
					Multiple Range (.05 level)					
Mean	461.11	573.56	595.22	607.44	617.33	620.78	635.33	638.89	644.78	704.67

Means underlined by a common line are not significantly different.

*51% stand due to winterkilling.

to have too much of its dry weight in stems.

No interaction was found between varieties and years in the analysis of dry weight of stems. This indicates that stems are produced in relatively the same quantity in each variety from year to year.

Yield of Heads

Average dry weights of heads per plot are shown in Table 6. Stanton Str. 1 Sel. and Bronco produced significantly greater yields of dry weight in the heads than the other varieties. Cimarron ranked 7th for the yield of dry weight from heads. However, data in Table 3 shows that Cimarron has a much greater percentage of dry weight in the heads than the other varieties. This can be explained by a low total plot yield of dry weight produced by Cimarron which directly reflects on the weight of each of its components. A highly significant difference was found among years and among varieties. This is directly reflected again in a highly significant interaction between years and varieties.

Grain Yield

Average yields of grain produced per plot are given in Table 7. It would seem that there should be a close relationship between the dry weight of partially developed heads (soft-dough stage) and yield of grain. This does not appear to be consistent and very little relationship can be shown. Stanton Str. 1 Sel. produced the highest yield of grain and also the greatest amount of dry weight in the heads. However, very little significance exists among the means of the 10 varieties for grain yield. The 8 highest grain yielders are not significantly different. This indicates that changes that are involved in the plants between the soft dough

Table 6. Average dry weight of heads for 10 winter oat varieties on a gram/plot basis for the years 1958-1960.

Year	Stw. 553452	Nysel	Arkwin	Cimarron	Atlantic	Arlington	Forkedeer	Colo X Wintok	Bronco	Stn. Str. 1 Sel.
1958	629.00	560.33	549.00	492.67	666.33	698.33	595.33	633.33	714.00	696.67
1959	361.67	380.67	552.23	520.67	502.33	508.67	542.67	508.67	469.33	604.00
1960	502.00	577.33	424.67	544.33	445.67	421.00*	527.67	553.33	596.00	551.33
					Multiple Range (.05 level)					
Mean	497.56	506.11	508.67	519.22	538.11	542.67	555.22	565.11	593.11	617.33

Means underlined by a common line are not significantly different.

*51% stand due to winterkilling.

Table 7. Average yield of grain for 10 winter oat varieties on a gram/plot basis for the years 1958-1960.

Year	Nysel	Colo X Wintok	Arlington	Forkedeer	Atlantic	Bronco	Stw. 553452	Cimarron	Arkwin	Stn. Str. 1 Sel.
1958	283.33	269.00	452.33	343.00	378.33	450.33	396.67	320.33	426.00	344.67
1959	192.33	287.00	346.33	329.33	305.00	169.00	321.67	432.00	379.00	390.00
1960	591.00	591.00	476.33*	605.67	612.67	678.00	595.33	599.00	563.67	652.00
					Multiple Range (.05 level)					
Mean	355.56	382.33	425.00	426.00	432.00	432.44	437.89	450.44	456.22	462.22

Means underlined by a common line are not significantly different.

*51% stand due to winterkilling.

stage of maturity and complete ripeness strongly influence the grain yield for each variety. Bronco had next to the highest yield of dry weight in heads. It ranked 5th in grain yield producing a high yield in 1958 and 1960, but an extremely low yield in 1959. This can be partially attributed to extreme lodging that occurred early in the fruiting period in 1959.

The grain yield of Arlington was markedly reduced in the 1960 season due to poor stands resulting from winterkilling. Giving consideration to a 51% stand at the end of the winter, this variety did compensate well. Nysel produced the lowest average grain yield for the 3-year period. As can be expected for a characteristic like grain yield, a highly significant year and variety interaction was found. A highly significant difference among years again was apparent for this characteristic as well as a highly significant difference among varietal means.

Tillering Ability

The average numbers of tillers per square foot for each variety are presented in Table 8. Colo X Wintok and Nysel both produced a much higher number of tillers than the other varieties. It is noteworthy that Colo X Wintok and Nysel rank 7th and 8th respectively for total dry weight produced per plot and 9th and 10th respectively for average grain yield produced per plot. This indicates that high tillering ability is not an indication of high hay and grain yielding capacity in winter oats. Forkedeer and Cimarron ranked 3rd and 4th respectively for number of tillers per square foot and were not significantly lower than Nysel. Stanton Str. 1 Sel., which was thought to be a heavy tillering variety, ranked 9th with an average of 50.33 tillers per square foot. Arlington produced a signi-

Table 8. Average number of tillers per square foot for 10 varieties of winter oats during the years 1958-1960.

Year	Arlington	Stn. Str. 1 Sel.	Stw. 553452	Atlantic	Arkwin	Bronco	Cimarron	Forkedeer	Nysel	Colo X Wintok
1958	53.33	57.67	64.67	65.33	84.00	80.00	79.33	82.33	81.67	102.00
1959	50.00	50.67	52.67	57.00	57.33	65.67	70.67	67.00	75.00	69.67
1960	21.00*	42.67	44.33	44.67	51.33	50.67	64.67	66.33	66.00	64.33
					Multiple Range (.05 level)					
Mean	41.44	50.33	53.89	55.67	64.22	65.44	71.56	71.89	74.22	78.67

Means underlined by a common line are not significantly different.

*51% stand due to winterkilling.

ficantly lower number of tillers than the other varieties. Poor stands resulting from winterkilling lowered the tiller count to 21 for this variety in 1960. However, Arlington produced the lowest number of tillers the 2 previous years and can be considered to have the poorest tillering ability regardless of the winterkilling.

It would seem that a character of this nature would be relatively consistent from year to year. However, this consistency did not occur since highly significant difference among years was found. As might be expected, a highly significant difference was found among the inherent tillering ability of the varieties. Again, a highly significant year and variety interaction was found.

Height

Average heights in inches for each variety during the 3 years are shown in Table 9. No significant difference existed among the mean heights for the 5 tallest varieties. Only 2 of the 5 tallest varieties, Arkwin and Stw. 553452, are among the 5 varieties which produced the greatest amounts of total dry matter. From these data it would seem that height is important in some varieties for high hay yield but not absolutely necessary.

The effect of different years on height is readily apparent. Although most of the varieties did not differ greatly, a highly significant difference was found among varieties. A highly significant year and variety interaction was found for height.

Table 9. Average height in inches for 10 winter oat varieties tested for the years 1958-1960.

Year	Cimarron	Bronco	Stn. Str. 1 Sel.	Nysel	Forkedeer	Arkwin	Colo X Wintok	Stw. 553452	Atlantic	Arlington
1958	40.00	48.00	50.67	49.00	48.33	48.00	47.67	51.00	50.33	53.33
1959	27.67	35.00	34.33	35.00	35.67	36.00	37.33	34.33	36.00	35.67
1960	32.67	36.67	36.67	38.00	38.33	39.00	39.33	40.00	40.00	37.33*
					Multiple Range (.05 level)					
Mean	33.44	39.89	40.56	40.67	40.78	41.00	41.44	41.78	42.11	42.11

Means underlined by a common line are not significantly different.

*51% stand due to winterkilling.

Maturity

Table 10 presents the average heading date expressed as number of days from April 1. Bronco is significantly later than the other varieties. However, it is only .22 of a day later than Nysel. As expected from previous observations, all varieties except Forkedeer and Arlington are significantly different in date headed. The 10 varieties headed over a period of 12.11 days. In all 3 years, Cimarron was earliest to head averaging nearly 4 days earlier than the next earliest variety, Stanton Str. 1 Sel.

Later maturing varieties have been reported to produce the greatest hay yields. However, it must be considered that late maturity allows more time for hazards of production to occur. The late varieties are ordinarily more susceptible to some diseases which build up in the latter part of the growing season and weather extremes which occur late in the growing season.

Actual heading dates as compared with harvesting dates at the soft dough stage of maturity are shown in Table 11. There was a pronounced variation from year to year for the heading and harvesting dates. A direct relationship is apparent between the date of heading and date of harvesting. This indicates that the heading date is a reliable index of the maturity of each variety.

Growth Habit

Growth habits observed for each variety during the 3 years this nursery was grown are presented in Table 12. A decumbent growth habit is generally considered, although not always true, as a good indication

Table 10. Average heading date (expressed as the number of days from April 1) for 10 varieties of winter oats tested during the years 1958-1960.

Year	Cimarron	Stn. Str. 1 Sel.	Arkwin	Atlantic	Stw. 553452	Colo X Wintok	Forkedeer	Arlington	Nysel	Bronco
1958	38.00	40.33	40.33	41.67	43.33	44.33	44.33	42.67	46.67	47.00
1959	27.00	33.33	34.67	35.33	34.00	35.67	36.67	33.67	41.33	41.00
1960	29.00	32.00	35.00	36.33	39.00	37.67	37.33	42.00*	41.67	42.33
					Multiple Range (.05 level)					
Mean	31.33	35.22	36.67	37.78	38.78	39.22	39.44	39.44	43.22	43.44

Means underlined by a common line are not significantly different.

*51% stand due to winterkilling.

Table 11. Date harvested for hay (soft dough) as compared to the average heading date for each variety during the years 1958-1960.

	1958		1959		1960		Av.	
	Headed	Harv.	Headed	Harv.	Headed	Harv.	Headed	Harv.
Arkwin	5-10	5-26	5-5	5-25	5-5	5-24	5-7	5-25
Arlington	5-13	5-28	5-4	5-25	5-12	5-30	5-9	5-28
Atlantic	5-12	5-26	5-5	5-25	5-6	5-24	5-8	5-25
Bronco	5-17	6-2	5-11	5-29	5-12	5-30	5-13	5-28
Cimarron	5-8	5-23	4-27	5-15	4-29	5-23	5-1	5-20
Colo X Wintok	5-14	5-30	5-6	5-27	5-8	5-27	5-9	5-28
Forkedeer	5-14	5-28	5-7	5-27	5-7	5-26	5-9	5-27
Stw. 553452	5-13	6-2	5-4	5-21	5-9	5-26	5-9	5-25
Nysel	5-17	5-26	5-11	5-29	5-12	5-31	5-13	5-31
Stanton Str. 1 Sel.	5-10	5-28	5-3	5-20	5-2	5-23	5-5	5-23
Average	5-13	5-28	5-5	5-24	5-7	5-26	5-8	5-26

Table 12. Growth habits[1/] observed for each variety for the years 1958-1960.

	1958	1959	1960	Av.
Arkwin	U	I-U	U	U
Arlington	I-U	I	I	I
Atlantic	I-U	I-U	I	I-U
Bronco	I-D	D-I	D	D-I
Cimarron	I	I	I	I
Colo X Wintok	I-U	I	I	I
Forkedeer	D-I	D-I	D	D-I
Stw. 553452	I-D	D-I	D	D-I
Nysel	D	D-I	D	D
Stanton Str. 1 Sel.	I	I	U	I

[1/] I = intermediate, U = upright, D = decumbent.

of winterhardiness. With actual winterkilling occurring only 1 year in a single variety, little data concerning winterhardiness is available from this experiment. The winterkilling that occurred was in the variety Arlington which had an intermediate to slightly upright habit of growth. Arkwin and Atlantic, which are somewhat more upright than Arlington, suffered no apparent winter injury.

DISCUSSION

Yield of Hay and Grain

This experiment was designed to test different oat varieties for hay yielding ability. Thurman et al. (25) believed that a high grain producing variety is preferable when sowing oats for hay so that if the hay is not needed, the crop can be harvested for grain. This characteristic has been given consideration in the testing of these oat varieties for hay. Also, the quality of the hay has not been overlooked. A variety with a high percentage of leaves and heads should definitely be more desirable for producing high quality oat hay.

Forkedeer, Stanton Str. 1 Sel., Bronco, Arkwin and Stw. 553452 were the 5 highest hay yielding varieties, in that order. The average grain yields of these 5 varieties did not differ significantly. Arkwin can be considered a poor hay type from a quality standpoint since it contains a high percentage of stems and a low percentage of leaves. Stw. 553452 could perhaps be considered unsatisfactory on a similar basis. It has a high percentage of leaves, but also a high percentage of stems which could perhaps lessen quality. Stanton Str. 1 Sel. which was 2nd highest in hay yield was highest in grain yield. It would appear to be the best of the 10 varieties. However, in tests of previous years under Oklahoma conditions Stanton Str. 1 Sel. has consistently produced low test weight grain which would be undesirable from the standpoint of a dual purpose variety.

Results from this study indicate that Bronco and Forkedeer appear to be the best prospective varieties for hay production in Oklahoma. Both varieties have produced good yields of grain on the average. Bronco which was severely damaged in 1959 still averaged well for the 3 year period. However, better disease resistance and stronger straw would be desirable for both varieties. From this experiment it appears that the breeder should strive for Forkedeer or Bronco types and improve other characteristics which affect hay and grain yield.

Atlantic ranked 6th in average hay yield and grain yield. This variety is similar to Arkwin with a high percentage of its dry weight in stems and a low percentage in leaves. This would probably result in a low quality hay.

Colo X Wintok and Nysel, both heavy tillering varieties, produced low yields of hay and grain. Both appear to have weak straw and seem to be out of their area of adaptation.

Arlington yielded well in hay and grain in 1958 and 1959. A 51% stand in the spring of 1960 resulting from winterkilling affected both hay and grain yield for 1960. The lack of winterhardiness eliminates Arlington as a possible type to be grown for hay or grain in Oklahoma.

Cimarron, which is short, early maturing and has been a high grain yielding variety in Oklahoma during previous years, cannot satisfactorily be compared with the other varieties for hay yield. As was expected, it consistently produced high yields of grain over the 3 years of the test. However, this variety appears to have little to recommend it as a hay type for Oklahoma.

Characters Studied

A number of characters that are reported to affect hay yield were studied. Percentages of dry weight contributed by various plant parts were first reported by Hendry and Woll (9). They reported that 4 varieties ranged from 21% to 32% heads while in the soft dough stage of maturity. A comparison can be made with their work since similar data were collected in this study. Their percentages appear to be somewhat low considering the average percentages of heads obtained from the ten varieties tested here.

Stotola (22) stated that the ratio of stem, leaf and head in a cereal plant affects both its nutritive value and chemical composition. This ratio was also reported to be a reliable and practical index of feeding value. If this is true, Forkedeer and Bronco, which possess ratios of leaves, stems and heads at 19.4%:42.9%:37.7% and 18.2%:41.6%:40.2%, respectively, should produce hay of somewhat higher feeding value than the other varieties.

Frey and Wiggans (7) expressed an opinion that tillering capacity may be one characteristic which may become important in the production of better oat varieties. Logically, a variety that produces abundant tillers should produce more hay than a variety that tillers poorly. However, high tillering ability alone does not appear to indicate high hay yield. Most of the varieties that produced high yields of total dry weight per plot seem to be neither extremely high nor extremely low in number of tillers produced per square foot. Apparently, number of tillers produced by a variety is important but this characteristic must be associated with other characters conducive to high yield.

The comparable heights of different oat varieties should be a very important characteristic determining hay yield. Cimarron, which produced the lowest yield of total dry weight per plot, was only 33.44 inches tall on the average for the 3 years. The other 9 varieties were in a very close range between 39.89 inches and 42.11 inches. The hay yield of Cimarron appears to be directly related to its height. Being much shorter, it should not be compared with the other varieties for hay yield. The difference of 2.22 inches among the average heights of the other varieties is probably too small a difference to have a pronounced affect on yield of hay.

Thatcher (23) stated that late and medium maturing varieties of oats yield more hay per acre than early varieties. This statement cannot be affirmed by data available from this study. Stanton Str. 1 Sel. and Arkwin headed next after the earliest variety, Cimarron, and can be considered to be at least medium if not early maturing. These 2 varieties ranked 2nd and 4th respectively in total yield of dry matter per plot. Cimarron, which is extremely early maturing, produced the least amount of total dry weight per plot. As mentioned previously, this low yield should be attributed to short stature and not to its early maturity. These data indicate that if there is a relationship between later maturity and higher hay yields it is only slight and certainly not a characteristic of importance.

Lodging was a factor observed throughout the period of this study. Nysel exhibited a very weak straw all 3 years, especially in 1958. Stanton Str. 1 Sel., Colo X Wintok and Forkedeer were observed to lodge. The problem of lodging is only serious if it occurs before the variety can be harvested for hay. Nysel is the only variety that would be unde-

sirable from a standpoint of weak straw for hay production.

Winterhardiness is a very serious problem that must be considered in Oklahoma. During the 3 years of the test, winterkilling occurred only once in a single variety, Arlington. There are possibly some of the other varieties included in this test which could not withstand extreme winter conditions. Thus, more information regarding winterhardiness is needed for these varieties.

Diseases are known to produce a marked effect on grain yield and in some cases affect hay yield by destroying leaves. However, diseases were not considered to have been severe enough to have affected the results of this experiment.

Methods

This study revealed that it is time consuming and tedious to test oats for hay yielding ability. Considering the various inherent plant characteristics which affect hay yield, accurate methods must be used to obtain results typical for each variety tested. The methods chosen for use in this test are from different sources. Some are similar to those previously reported in the literature, others are standard methods used in testing small grain crop varieties and the remaining ones are original.

The results obtained from various methods utilized during this test appear to be valid. Minor modifications of some of the methods could perhaps give more accurate and typical results. Dry weight of hay is usually presented as air-dry hay rather than oven-dry hay as used in this test. It must be recognized that oven-dry material has practically all the moisture removed and temperature can be controlled, thus enabling a

comparison of varieties under uniform conditions. Hay harvested during this experiment was removed at ground level so that all stem and leaf material could be included. By leaving a stubble similar to that left by machines used for harvesting hay by the farmers, more typical results could perhaps be obtained. The weight of heads could perhaps be yet further broken down into subdivisions which would give more accurate results.

The yield of grain could have been affected slightly by lodging which occurred after rows 3 and 4 were removed from each plot. This would apparently affect the earlier maturing varieties which generally remained in the field longer prior to harvesting.

Breeding for Hay Type Oats

This experiment indicates that a breeding program concentrating on hay yielding ability of oats could be initiated. Two varieties, Bronco and Forkedeer, already on the list of recommended varieties for Oklahoma, appear to be among the better hay yielding varieties and produce acceptable yields of grain if that alternative is chosen. It would seem that the 2 above mentioned varieties and Stanton Str. 1 Sel. could provide sufficient germplasm to breed oats for hay yield and yet maintain high yields of grain. Each of these varieties is desirable as a hay yielding type because of different characters. If the desirable characters of each of these 3 varieties could be associated into one variety, it would surely be the ultimate variety for hay production. However, in addition to the plant characteristics studied in this experiment, consideration should be given to disease resistance. Resistance to prevalent diseases would surely be of value in making a new variety a successful one.

SUMMARY

The yielding ability of 10 varieties of winter oats was studied over a period of 3 continuous years, 1958-60. A number of plant characteristics were studied to investigate their relationship to yield and quality of hay.

The main objectives of the research were: (1) to determine which varieties or strains of oats adapted to Oklahoma produce the greatest yields of hay; (2) to determine the quality of the hay by utilizing the relationship of 3 plant components (heads, leaves and stems); (3) to determine if any of the varieties or strains tested were suitable for a dual purpose, i.e., production of high yields of grain as well as high yields of hay.

Among the 5 varieties that produced the highest yields of dry matter per plot, Forkedeer and Bronco seem to offer the best possibility as hay producing oat varieties for Oklahoma. Arkwin and Stw. 553452 yielded well in dry weight per plot but both characteristically had high percentages of stems. Stanton Str. 1 Sel. produced the 2nd highest yield of dry matter per plot and the highest yield of grain. However, in previous tests this variety has produced grain of low test weight and undesirable quality. Stanton Str. 1 Sel. rather than being used as a variety seems to offer a better possibility as a source of germplasm for developing new and better varieties.

Forkedeer produced what would appear to be the highest quality of

hay with 19.4% of its dry weight in leaves. Stanton Str. 1 Sel. and Bronco produced the highest dry weights in the heads which is typical of high grain yielding types.

Of the other plant characteristics studied, height appeared to contribute most to hay yield. Tillering ability seems to be of importance when combined with other desirable characters. No relationship could be established between plant maturity and hay yield.

It was concluded that Bronco, Forkedeer and Stanton Str. 1 Sel. are excellent sources of germplasm for development of new high yielding grain or hay type oats. Further, it was concluded that until new varieties can be developed that Bronco and Forkedeer, already recommended varieties for Oklahoma, can satisfactorily provide high yields of hay or grain for the farmer.

LITERATURE CITED

1. Ahlegren, G. H. Forage Crops. McGraw-Hill Book Co., N.Y., Second Edition. 1956.

2. Atkins, I. M. Bronco, a new winter-hardy, high-yielding oat variety for Texas and other Southern States. Tex. Agr. Exp. Sta. L-309. 1956.

3. Bartlett, J. M. Oats as grain and fodder. Maine Agr. Exp. Sta. Bul. 70. 1901.

4. Chaffin, W. and E. Granstaff. Crop varieties recommended for Oklahoma. Okla. Agr. Exp. Sta. Cir. E-653. 1959.

5. Coffman, F. A., H. A. Rodenhiser and J. W. Taylor. New varieties for the Northern Winter Oat Regions. Jour. Amer. Soc. Agron. 41: 551-554. 1949.

6. Duncan, D. B. Multiple range and multiple F tests. Biometrics 11: 1-42. 1955.

7. Frey, K. J. and S. C. Wiggans. Tillering studies in oats I: Tillering characteristics of oat varieties. Agron. Jour. 49: 48-50. 1957.

8. Guilbert, H. R. Wild oat hay for fattening yearling steers. Cal. Agr. Exp. Sta. Bul. 481. 1929.

9. Hendry, G. W. and F. W. Woll. I. Cereal hay production in California; II. Feeding trials with cereal hays. Cal. Agr. Exp. Sta. Bul. 394. 1925.

10. Jensen, N. F. Breeding winter oats for New York. Fm. Res. 24: 6. 1958.

11. Justus, N. and R. L. Thurman. The effect of clipping and grazing on the subsequent growth of winter oats. Agron. Jour. 47: 82-83. 1955.

12. Keith, T. E. and F. C. Tarbox. Changes in composition of the oat plant as it approaches maturity. S. C. Agr. Exp. Sta. Bul. 163. 1912.

13. Meyer, J. H., W. C. Weir, L. G. Jones and J. L. Hull. The influence of stage of maturity on feeding value of oat hay. J. Ani. Sci. 16: 623-632. 1957.

14. Morey, D. D., W. H. Chapman and R. W. Earhart. Growing oats in Florida. Florida Agr. Exp. Sta. Bul. 523. 1953.

15. Morrison, F. B. Feeds and Feeding. The Morrison Publishing Co., N.Y. Twenty-first Edition. 1951.

16. Phillips, M., M. G. Goss, B. L. Davis and H. Stevens. Composition of the various parts of the oat plant at successive stages of growth with special reference to the formation of lignin. Jour. Agr. Res. 59: 319. 1939.

17. Rosen, H. R., W. J. Wiser and J. O. York. Arkwin, a disease-resistant oat and comparisons of small grains as winter forage. Ark. Agr. Exp. Sta. Bul. 533. 1953.

18. Schlehuber, A. M. Cimarron oats. Okla. Agr. Exp. Sta. Bul. B-457. 1955.

19. Snedecor, G. W. Statistical methods. Ia. State College Press. Ames. Fifth Edition. 1956.

20. Stanton, T. R. Oat identification and classification. U.S.D.A. Tech. Bul. 1100. 1955.

21. _____ and F. A. Coffman. Winter oats for the South. U.S.D.A. Farmers Bul. 2037. 1951.

22. Stotola, J. The chemical composition and nutritive value of certain cereal hays as affected by plant maturity. Jour. Agr. Res. 54: 399-415. 1937.

23. Thatcher, L. E. Cereal hays for Ohio. Ohio Agr. Exp. Sta. Bul. 543. 1934.

24. Thompson, R. K. and A. D. Day. Spring oats for winter forage in the Southwest. Agron. Jour. 51: 9-12. 1959.

25. Thurman, R. L., O. T. Stallcup, J. L. Stephens and N. E. Justus. When to harvest oats for hay and silage. Ark. Agr. Exp. Sta. Bul. 586. 1957.

26. Wilson, H. K. Grain Crops. McGraw-Hill Book Co., N.Y. 1955.

A P P E N D I X

APPENDIX

TABLE OF CONTENTS

App. Table 1. Yield of dry matter in grams per plot for the years 1958-60.

Variety	1958 Replications I	II	III	Av.	1959 Replications I	II	III	Av.	1960 Replications I	II	III	Av.	Average
Arkwin	1684	1639	1653	1658.67	1568	1429	1480	1492.33	1253	1160	1222	1211.67	1454.22
Arlington	1715	1732	1636	1694.33	1279	1293	1511	1361.00	924	848	1097	956.33	1337.22
Atlantic	1579	1670	1593	1614.00	1355	1315	1267	1312.33	1134	1177	1196	1169.00	1365.11
Bronco	1735	1656	1692	1694.33	1426	1383	1378	1395.67	1400	1554	1040	1331.33	1473.78
Cimarron	1270	1262	1219	1250.33	992	1134	1077	1067.67	975	1060	1403	1146.00	1154.67
Colo X Wintok	1366	1253	1440	1353.00	1435	1477	1366	1426.00	1236	1264	1412	1304.00	1361.00
Forkedeer	1588	1622	1678	1629.33	1769	1355	1366	1496.67	1290	1332	1327	1316.33	1480.78
Stw. 553452	1639	1786	1494	1639.67	1256	1279	1392	1309.00	1091	1262	1406	1253.00	1400.56
Nysel	1517	1537	1554	1536.00	1108	1250	1208	1188.67	1317	1366	1281	1321.33	1348.67
Stanton Str. 1 Sel.	1695	1710	1678	1694.33	1429	1503	1534	1488.67	1324	1157	1264	1248.33	1477.11

App. Table 2. Grams of dry matter in the leaves per plot for the years 1958-60.

Variety	1958 Replications I	II	III	Av.	1959 Replications I	II	III	Av.	1960 Replications I	II	III	Av.	Average
Arkwin	236	311	291	279.33	282	287	268	279.00	163	153	172	162.67	240.33
Arlington	276	262	237	258.33	308	255	340	301.00	95	87	128	103.33	220.89
Atlantic	215	266	231	237.33	312	267	223	267.33	159	156	148	154.33	219.67
Bronco	240	223	191	218.00	436	411	318	388.33	176	213	161	183.33	263.22
Cimarron	170	206	208	194.67	151	186	154	163.67	106	136	196	146.00	168.11
Colo X Wintok	321	283	311	305.00	338	306	240	294.67	156	139	178	157.67	252.44
Forkedeer	329	298	305	310.67	442	325	282	349.67	191	219	220	210.00	290.11
Stw. 553452	279	305	269	284.33	344	361	331	345.33	133	151	202	162.00	263.89
Nysel	272	267	166	235.00	330	336	287	317.67	194	190	185	189.67	247.44
Stanton Str. 1 Sel.	215	258	233	235.33	317	374	272	321.00	168	149	162	159.67	238.67

App. Table 3. Grams of dry matter in the stems per plot for the years 1958-60.

Variety	1958				1959				1960				Average
	Replications				Replications				Replications				
	I	II	III	Av.	I	II	III	Av.	I	II	III	Av.	
Arkwin	845	819	826	830.00	696	630	655	660.33	651	585	635	623.67	704.67
Arlington	741	769	703	737.67	511	527	615	551.00	408	386	502	432.00	573.56
Atlantic	698	746	688	710.67	564	543	522	543.00	532	572	602	568.67	607.44
Bronco	748	732	807	762.33	538	549	526	537.67	580	654	422	552.00	617.33
Cimarron	577	569	543	563.00	345	382	366	364.33	396	419	553	456.00	461.11
Colo X Wintok	660	704	793	719.00	640	638	589	622.33	575	594	610	593.00	644.78
Forkedeer	695	741	733	723.00	734	539	540	604.33	575	584	577	578.67	635.33
Stw. 553452	693	807	678	726.00	568	588	650	602.00	515	608	643	588.67	638.89
Nysel	769	731	721	740.33	431	545	494	490.00	556	577	533	555.33	595.22
Stanton Str. 1 Sel.	758	769	759	762.00	537	595	558	563.33	596	483	532	537.00	620.78

App. Table 4. Grams of dry matter in the heads per plot for the years 1958-60.

Variety	1958				1959				1960				Average
	Replications				Replications				Replications				
	I	II	III	Av.	I	II	III	Av.	I	II	III	Av.	
Arkwin	603	508	536	549.00	589	511	557	552.33	439	421	414	424.67	508.67
Arlington	698	702	695	698.33	459	511	556	508.67	422	374	467	421.00	542.67
Atlantic	667	658	674	666.33	480	505	522	502.33	443	448	446	445.67	538.11
Bronco	748	700	694	714.00	452	423	533	469.33	644	687	457	596.00	593.11
Cimarron	523	487	468	492.67	496	509	557	520.67	473	506	654	544.33	519.22
Colo X Wintok	617	629	654	633.33	456	533	537	508.67	505	531	624	553.33	565.11
Forkedeer	564	582	640	595.33	593	490	545	542.67	524	530	529	527.67	555.22
Stw. 553452	667	673	547	629.00	344	330	411	361.67	443	502	561	502.00	497.56
Nysel	476	538	667	560.33	347	369	426	380.67	568	600	564	577.33	506.11
Stanton Str. 1 Sel.	722	682	686	696.67	574	534	704	604.00	560	524	570	551.33	617.33

App. Table 5. Total yield of grain in grams per plot for the years 1958-60.

Variety	1958 Replications I	II	III	Av.	1959 Replications I	II	III	Av.	1960 Replications I	II	III	Av.	Average
Arkwin	420	468	390	426.00	398	324	415	379.00	561	526	604	563.67	456.22
Arlington	525	392	440	452.33	312	345	382	346.33	532	545	352	476.33	425.00
Atlantic	446	344	345	378.33	260	340	315	305.00	531	643	664	612.67	432.00
Bronco	530	421	400	450.33	185	84	238	169.00	603	697	734	678.00	432.44
Cimarron	460	296	205	320.33	400	434	462	432.00	532	590	675	599.00	450.44
Colo X Wintok	373	219	215	269.00	265	252	344	287.00	561	588	624	591.00	382.33
Forkedeer	403	364	262	343.00	300	312	376	329.33	565	604	648	605.67	426.00
Stw. 553452	450	370	370	396.67	245	340	380	321.67	558	568	660	595.33	437.89
Nysel	364	226	260	283.33	162	235	180	192.33	549	613	611	591.00	355.56
Stanton Str. 1 Sel.	415	269	350	344.67	337	418	415	390.00	691	624	641	652.00	462.22

App. Table 6. Average number of tillers per square foot for the years 1958-60.

Variety	1958 Replications I	II	III	Av.	1959 Replications I	II	III	Av.	1960 Replications I	II	III	Av.	Average
Arkwin	81	80	91	84.00	52	60	60	57.33	57	47	50	51.33	64.22
Arlington	48	57	55	53.33	47	53	50	50.00	26	22	15	21.00	41.44
Atlantic	72	68	56	65.33	50	59	62	57.00	44	45	45	44.67	55.67
Bronco	74	88	78	80.00	71	63	63	65.67	44	53	55	50.67	65.44
Cimarron	84	83	71	79.33	64	73	75	70.67	60	71	63	64.67	71.56
Colo X Wintok	103	93	110	102.00	68	64	77	69.67	62	61	70	64.33	78.67
Forkedeer	79	93	75	82.33	64	70	67	67.00	68	70	61	66.33	71.89
Stw. 553452	64	64	66	64.67	49	52	57	52.67	44	39	50	44.33	53.89
Nysel	90	79	76	81.67	74	71	80	75.00	57	73	68	66.00	74.22
Stanton Str. 1 Sel.	58	55	60	57.67	47	52	53	50.67	47	39	42	42.67	50.33

App. Table 7. Average height per plot in inches for each variety during the years 1958-60.

Variety	1958				1959				1960				Average
	Replications				Replications				Replications				
	I	II	III	Av.	I	II	III	Av.	I	II	III	Av.	
Arkwin	47	47	50	48.00	35	36	37	36.00	39	39	39	39.00	41.00
Arlington	52	56	52	53.33	33	37	37	35.67	36	38	38	37.33	42.11
Atlantic	51	50	50	50.33	34	37	37	36.00	39	40	41	40.00	42.11
Bronco	48	48	48	48.00	35	34	36	35.00	35	37	38	36.67	39.89
Cimarron	40	40	40	40.00	27	28	28	27.67	32	32	34	32.67	33.44
Colo X Wintok	47	48	48	47.67	38	36	38	37.33	39	39	40	39.33	41.44
Forkedeer	49	49	47	48.33	32	36	39	35.67	37	39	39	38.33	40.78
Stw. 553452	50	52	51	51.00	31	37	35	34.33	40	40	40	40.00	41.78
Nysel	49	49	49	49.00	33	37	35	35.00	37	38	39	38.00	40.67
Stanton Str. 1 Sel.	52	50	50	50.67	34	34	35	34.33	37	36	37	36.67	40.56

App. Table 8. Date of heading expressed as the number of days from April 1 for the three years 1958-60.

Variety	1958				1959				1960				Average
	Replications				Replications				Replications				
	I	II	III	Av.	I	II	III	Av.	I	II	III	Av.	
Arkwin	40	40	41	40.33	34	35	35	34.67	35	35	35	35.00	36.67
Arlington	43	42	43	42.67	33	34	34	33.67	42	42	42	42.00	39.44
Atlantic	40	42	43	41.67	36	35	35	35.33	37	35	37	36.33	37.88
Bronco	47	47	47	47.00	41	41	41	41.00	42	42	43	42.33	43.44
Cimarron	38	38	38	38.00	27	27	27	27.00	29	29	29	29.00	31.33
Colo X Wintok	44	44	45	44.33	36	36	35	35.67	38	38	37	37.67	39.22
Forkedeer	44	44	45	44.33	37	37	36	36.67	37	37	38	37.33	39.44
Stw. 553452	43	44	43	43.33	34	34	34	34.00	39	39	39	39.00	38.78
Nysel	46	47	47	46.67	41	42	41	41.33	40	42	43	41.67	43.22
Stanton Str. 1 Sel.	39	41	41	40.33	34	33	33	33.33	32	32	32	32.00	35.22

VITA

Dennis Peier

Candidate for the degree of

Master of Science

Thesis: RELATIVE HAY YIELDING ABILITY OF TEN VARIETIES OF WINTER OATS AND ANALYSIS OF PLANT CHARACTERISTICS WHICH AFFECT YIELD AND QUALITY OF OAT HAY

Major Field: Agronomy (Field Crops)

Biographical:

Born: March 2, 1936 at Pond Creek, Oklahoma.

Undergraduate Study: Oklahoma State University 1954-1958.

Graduate Study: Oklahoma State University 1958-1960.

Experiences: Student Laborer at the Small Grains Section of the Agronomy Department, Oklahoma State University 1955-1958; Infantry Officer, U.S. Army, 1958-59; Graduate assistant in Agronomy, Oklahoma State University 1959-1960.

Member: Alpha Zeta, Phi Sigma.

Date of Final Examination: July, 1960.