GRAIN AND HAY YIELDING ABILITY OF TWENTY-THREE VARIETIES OF TRITICALE

By

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CHAPTER I

INTRODUCTION

With a steadily increasing demand for food products due to the increased world population, larger production of grain and forage will be needed. The production of hay from different cereal crops is a very ancient agriculture practice and many countries still use it. However, this source of feed is not enough to meet the great production of meat which is needed to feed the world population. Man searches for ways to increase farm crops productivity by breeding better varieties, improving the nutritional value of crops, and using good production practices.

Triticale is thought by some to have great potential as fresh fodder due to its relatively high protein content, good palatability and high lysine content. Also triticale has sometimes exceeded other small grains in yield. However, there are many production weaknesses in the plant that need to be corrected. No information is available at the present time concerning hay production of different varieties of triticale adapted to Oklahoma. Most of the varieties of triticale currently available are spring types and possess variable degrees of winterhardiness.

The breeding program at Oklahoma State University stresses the development of winter types or intermediate types for forage production. Hay quality and yield information is needed. Information regarding the percentage of leaves, stems, and spikes contributed by each variety will aid the breeding program. Also, information concerning grain yield is important in the development of new triticale varieties.

The objectives of this study are to:

1. Determine which existing varieties of triticale adapted to Oklahoma will produce the greatest yield and best quality of hay.
2. Determine which existing varieties of triticale adapted to Oklahoma will produce the greatest yield of grain.
3. Determine the agronomic characteristics of the triticale varieties under Oklahoma conditions.

CHAPTER II

REVIEW OF LITERATURE

Triticale is the first man-made species. It results from a cross between wheat and rye followed by doubling the chromosome number of the resulting hybrid. This hybrid has been shown to have superior nutritional qualities over wheat and rye. Such crosses are not new. Workers all over the world have made crosses between these two crops. The first hybrid between wheat and rye was reported and described by Wilson (35) in England in 1876. He obtained two hybrid plants but both of them were sterile; therefore, the hybrid was not carried further than the first generation. Carmen (20) in the United States in 1884 made a cross between wheat and rye. A few hybrid seeds were produced with which experimentation was continued. The hybrid plants were open pollinated, and they were grown to a limited extent. Leighty and Sands (21) reported that wheat-rye hybrids were found in experimental wheat plots at Arlington Experimental Farm near Washington, D.C. However, they were sterile.

Muntzing (23) in Sweden during the early 1900's started working with triticale using the amphiploid which arose from a hexaploid wheat X rye cross. Also, he made interstrain crosses and studied the wide range of variability in fertility, meiotic stability, and seed quality. According to Muntzing, triticale should be adapted to conditions of soil and climate that are intermediate between those which are optimum for wheat and those which are optimum for rye. Pissarev (27) who began his program on triticale in Russia early in 1940 reported progress in the hybridization of selections within triticale. In 1954 an intensive triticale breeding program was initiated in Canada at the University of Manitoba. The first variety of triticale (Rosner) was released by the Canada Department of Agriculture in 1968 (37). In 1965 a triticale breeding program was initiated in Mexico by Centro Internacional de Mejoramienta de Maize Trige (CIMMYT). The main objective of this program as it exists today is the development of triticale for human food (12).

During the early days of triticale improvement emphasis was devoted to the octaploid type (AABBDDRR) which was developed by crossing hexaploid wheat as the female with diploid rye as the male (AABBDD X RR). The F_1 hybrids from the above cross are extremely sterile. They contain the ABD genomes from wheat and the R genome from rye. The F_1 hybrids are treated with colchicine to double the chromosome numbers and produce octaploid plants (AABBDDRR) with a chromosome number of $2n = 56$ (18)(24)(27).

After several years of research, workers discovered that hexaploid triticale was more efficient as a seed producer than the octaploid triticale. Hexaploid triticale was originally produced by crossing tetraploid wheat (AABB) as the female with diploid rye as the male (AABB X RR). The F_1 hybrids from the above cross are extremely sterile. They contain the AB genomes from wheat and the R genome from rye. F_1 hybrids are treated with cochicine to double the chromosome numbers and produce hexaploid plants (AABBRR) with a chromosome number $2n = 42$ (24)(18)(27).

Krolow (16) suggested that the tetraploid level of polyploidy may be more efficient than either the hexaploid or octaploid levels. He gave three methods to produce the tetraploid triticale. The most successful method was crosses between hexaploid triticale and diploid rye (AABBRR X RR). The F_1 hybrids from this cross would contain (ABRR) genomes, and this should be followed by five to six generations of selfing. The fertility after the fourth generation was relatively high indicating that complete genomes had been recovered.

Another recent method proposed to produce hexaploid triticale was by crossing octaploid triticale with hexaploid triticale. Pissarev (27) indicated that these secondary hexaploids were superior to primary hexaploids in a number of agronomic characteristics (27)(20).

Triticale for Forage Production

Triticale for forage and grazing has received little attention. In the United States triticale was compared for forage production with wheat, oats, rye and barley (19). This data indicated that triticale was about equal to wheat, oats, rye and perhaps slightly higher than barley in forage production.

Watson *et al*. (34) in 1971 conducted a study to evaluate some varieties of triticale for forage and grain production. They found that triticale produced substantially less total forage from September to June than did winter wheat, barley, rye and oats. Also they noted that some varieties produced a good amount of forage in early fall but total forage yield was low due to severe winterkilling. The varieties which they grew had spring growth habits.

According to Holt (11) frequent clippings of small grains results in reduced plant growth and reduced forage yields. Time between clippings should be at least four to six weeks to allow for recovery and regrowth. Severe clipping affects total plant development and rapidity of recovery following clipping. According to Elder (9) the yield of forage from small grains increased as the period between cuttings was extended from 15 to 60 days.

Sprague (31) reported that rye and wheat were similar in regard to maximum seasonal growth. The annual forage production of the rye and wheat was about 14 percent higher when grazed both fall and spring compared with spring grazing alone. In the spring of the year, previously fall grazed wheat and rye yielded 25 to 30 percent less than plots which were not grazed in the fall. In the case of oats the reduction was about 45 percent.

Klebsabel and Smith (14) conducted a study to determine the effect of harvesting oats at four stages of maturity on total forage yield. They reported a greater dry matter yield from a single harvest in the late milk stage through the mature stage than from two to three harvests made earlier.

Statola (32) conducted a study to determine the chemical composition and the nutritive value of cereal plants and of two legumes at different stages of maturity. He found that in the young stage the composition of dry matter of the cereal to be practically identical with that of alfalfa and sweet clover. As cereal plants develop, the ash, protein, and fat decreased and the fiber in the stem increased. He concluded that the proportion of stems, leaves, and spikes from a cereal plant affects both its nutritive value and chemical composition.

Woll (36) carried on feeding trials with four cereal plants: wheat, oats, barley and rye. As the result of his experiment, he concluded that the immature cereal hay is richer in protein and contains less fiber than mature cereal hay. As cereal plants reach the milk stage to the soft dough stage, the protein decreases and fiber increases.

The distance from the soil line that hay should be cut is also important in regard to nutrient value. Bartlett (2) cut the plants at three levels. One portion included the first eight inches from the lower part of the stalk. Another cut was made at the second eight inches, and the third included the remainder of the plant. He found that the first section had very little nutrient value and contained only 2.77 percent protein and 1.90 percent fat. It was also less digestible than the other sections. The second section had only one-half the protein of the top section and its digestibility was less than the top section. He recommended that a high stubble from eight to ten inches be left. The loss incurred by leaving the coarse part of the stalk on the ground should be more than compensated for by the improved quality and palatability of the hay.

Triticale for Grain Production

Watson et al. (34) in 1971 conducted a study to evaluate some varieties of triticale for grain and forage yield production. They found that the grain yield of all triticale varieties were equal or exceeded the yield of other small grains when grown in spring sown trials.

A study to compare the different types of triticales in ability to yield under Oklahoma's conditions was made in 1972 (25). Twenty triticale varieties and lines were grown and evaluated at five locations. T-205 had the highest yield of 3541 pounds per acre at Goodwell (irrigated). The highest average yielding variety was Pathfinder, which had an average yield at all locations of 1875 pounds per acre. CL-72, Stafford 208, and T-208 ranked second, third and fourth, respectively, in average yield. A similar study was conducted in 1973 (26) and the winter triticales had the best yields. Three of these varieties (T-131, OK 72179, and Kansas sel) exceeded the average yield of Scout 66 wheat. T-131 ranked first in the state averaging 2568 pounds per acre. For the spring types, the variety T-205 ranked first and had an average yield of 2258 pounds per acre.

In North Dakota triticale has been tested since 1968 (5). The results indicated that barley and oats yielded higher than triticale in grain yield. The workers concluded that available varieties of triticale could not be recommended for commercial production in North Dakota because of the lower yields when compared to oats and barley and because of their susceptibility to ergot.

The Feeding Value of Triticale

Triticale is high in protein (33). It also contains significantly more lysine than most cereal grains. At the University of Manitoba (37), large-scale animal feeding trials using triticale indicated that triticale as a feed was equal in nutritional value to wheat or barley.

Shimada _et al_. (30) conducted an experiment to study the nutritive value of triticale for growing swine. They found that triticale was equivalent to sorghum plus a part of the soybean meal in a standard ration. Cornejo _et al_. (7) in 1972 conducted a study to compare triticale, wheat, barley and corn for growing swine where the diets contained 95 percent of each grain. They found that a triticale sample containing 15.3 percent crude protein was equivalent to wheat and corn and superior to barley. A similar study was conducted in 1973 (6). The gross energy values for barley, wheat, and triticale were similar but lower than that for corn.

Workers at North Dakota State University (10) compared triticale with barley for growing and finishing hogs. They reported that triticale depressed feed consumption and daily gain. The degree of depression appeared to be related to whether or not the triticale had been cleaned prior to feeding. They recommended that triticale be limited to a maximum of 25 percent of the ration for growing pigs and 50 percent of the grain mixture for finishing pigs. According to Allee (1) triticale can be substituted on a weight basis for sorghum grain in a growing pig ration without any influence on performance.

Bixler et al. (3) in 1968 conducted a preliminary study with chicks in which they compared triticale with corn, wheat, and rye. They found that the nutritive value of triticale grain was equal to that of rye but below the value of corn and wheat. Bragg et al. (4) in 1970 compared the nutritional value of triticale and wheat for growing chicks. They found that triticale could replace wheat, either in part or completely, without adverse effect on growth or feed efficiency. However, it should be noted that their diets contained ingredients that were good sources of lysine.

Regarding the use of triticale in ruminant ration, Moody (23) reported that triticale was equal to barley as an energy source for lactating cows with no acceptability problems. Lofgreen et al. (22)

reported that triticale was equal to barley and superior to grain sorghum when all grains were steam rolled and fed in a ration for finishing steers.

Triticale grain was reported to be a good source of protein with fairly high lysine content. Knipfel (15) supported this when he compared the protein quality of triticale with protein quality of wheat and rye. He concluded that the protein efficiency ratio of triticale was similar to that of rye and superior to the protein efficiency ration for wheat.

CHAPTER III

MATERIALS AND METHODS

This study was conducted during the 1974-75 growing season on the Agronomy Research Station, Stillwater, Oklahoma. Twenty-three varieties of triticale were tested to obtain information relative to hay and grain yielding ability. One variety, Scout 66, of wheat was included as a check. The varieties were chosen on their contrasting characters and present or potential usefulness as varieties or breeding lines. A brief description of the varieties is presented below.

Pathfinder (8) is a spring type with fair winterhardiness. Forage production has been described as fair in early fall and poor in late spring due to severe winterkilling. Forage production is approximately 50 to 55 percent as much as Elbon rye or Agent wheat. Grain yields are 50 to 75 percent as much as Scout 66 wheat.

T-209 (8) is a spring type. Height is 92 to 102 centimeters, and maturity is ten days later than wheat varieties. It has fair to poor winterhardiness. Forage production is fair in early fall and poor in late spring due to severe winterkilling, and the forage production is approximately 50 to 55 percent as much as Agent wheat. Test weight is 48 lbs/bu.

Cl 72 (8) is a tall late maturing variety of triticale. It is about a week to ten days later than wheat varieties. CL 72 is a spring type with poor winterhardiness. Forage production is fair in early and poor in late spring due to severe winterkilling. Grain yield is 50 to 75 percent as much as Scout 66 wheat.

T-208 and Stafford 208 are spring types and are similar to Pathfinder in agronomic characteristics.

T-204 is a spring type. Plants are blue-green in color with white chaff at maturity. It is a tall variety of triticale and is late in maturity. It is about a week to ten days later than wheat varieties. Forage production is fair in early fall and poor in late spring. Test weight is about 46-47 lbs/bu. It is less winterhardy than T-208 or Pathfinder (8).

T-205 is a spring type and is similar to T-204 in varietal characteristics.

T-206 is a spring type with characteristics similar to T-204. However, it may be slightly more winterhardy than T-204 variety.

T-418 is a spring type similar to T-204 with slightly less winterhardiness (8).

T-131 is a winter type of triticale. Height is about 96-102 centimeters, and plant color is dark green. T-131 has a lower test weight than T-208 but more winterhardiness. Forage production is greater than T-208 with about 75 to 100 percent as much as Elbon rye or Agent wheat. The forage distribution of T-131 is similar to wheat. However, it has more late season forage than Scout 66 and less early spring forage than wheat. Grain yield is about 50 to 75 percent as much as Scout 66. Kans sel, OK 72179 and NB 69150 are winter types of triticale and are similar to T-131.

T-385 (8) is an intermediate type. However, it appears to have sufficient winterhardiness to survive winters in Oklahoma. It has a high test weight and has the same weight as T-208 and T-204. T-385 appears to be better than T-131 for forage production. Grain yields are good.

Design and Field Layout

The experimental design used for this study was a randomized complete block design with four replications grown on a Kirkland silt loam soil. Each replication contained 24 plots. The plots consisted of four rows, ten feet long (3.05 m) with row to row spacing of one foot (30.5 cm). A preplant fertilizer application 224.2 kg/ha (18-46-0), and nitrogen top dressing 178.15 kg/ha (34-0-0) in the spring was applied.

Characters Evaluated

The characters evaluated were (a) hay yields, (b) grain yields, (c) tiller number, (d) plant height, (e) protein content, and (f) leaf area.

Hay Yield

This trait was determined by harvesting a one foot area from row one or four when the variety reached the soft dough stage. Leaves, stems and spikes were separated in each sample. Leaves were removed at the ligule, the spikes were separated at the apex of the peduncle, and the stems were cut in three and four inch sections to facilitate handling. Each component was weighed and placed in a small sack and oven dried at 60°C for one week. The yield of leaves, stems and spikes was later converted and recorded as kg/ha.

Grain Yield

This trait was determined by harvesting 16 feet from the two center rows. The yield of the grain was recorded as grams per 16 square feet and then converted to kg/ha.

Tiller Number

This was determined by counting the number of spike-bearing tillers in one square foot of row and recorded as number of tillers per square foot.

Plant Height

This was recorded after all plots had flowered and was recorded as the distance in centimeters from the soil line to the tip of the spike excluding awns.

Protein Content

The three plant components (leaves, stems, and spikes) were mixed together and ground. One gram of the ground sample was used to determine protein content by the standard Kjeldahl method (14).

Leaf Area

This was determined by a portable area meter (Model Li-3000). Five tillers were selected at random in each plot and readings were taken on the first and second leaves on each tiller.

Statistical Analysis

The statistical analyses of variance for the data collected was done on an IBM 360/65 computer at the Oklahoma State University Computer Center. Analysis of variance was performed on each trait to determine differences among varieties. Cross produce analyses were done to determine the relationship between hay yield and other characters, and between grain yield and other characters.

The coefficient of correlation between two variables X and Y is determined from the formula (29).

$$r = \frac{\Sigma XY}{\Sigma X^2 \ \Sigma Y^2}$$

where ΣX^2 is the sum of squares of the deviations of the variable X, ΣY^2 is the sum of squares of the deviation of the variable Y, and ΣXY is the sum of products of the deviations of X and Y.

CHAPTER IV

RESULTS AND DISCUSSION

Yield of Green Matter

The analysis of variance for the total green matter and its three components are presented in Table I. The total yield of green matter for 23 varieties of triticale and one variety of wheat are presented in Table II. The differences among varieties were significant at .05 level of probability (Table I). The five highest yielding varieties were (T-876, T-522, T-131, Stafford 208 and OK 697947). The first three of those are winter types while the last two are spring types. Scout 66 the wheat check, recorded the lowest total green matter, being significantly lower than the ten highest yielding varieties. A highly significant correlation (Table III) was found between total green matter and number of tillers (r = 544**). The varieties with high number of tiller had more total green matter.

A highly significant difference was found in the yield of green stems among the varieties (Table I). The green weight of stems (kg/ha) for 23 varieties of triticale and one variety of wheat are presented in Table IV. (T-876, T-522, T-131 and Kans sel) produce a significantly greater amount of green stems than the other varieties, all of these are winter type varieties. Scout 66 was in the lower group when evaluated for stem green weigh. A highly significant correlation

TABLE I

MEAN SQUARES FOR STEMS, LEAVES, SPIKES AND TOTAL GREEN WEIGHT OF TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Source of Variation	d.f.	Green Weight			
		Stems	Leaves	Spikes	Total
REP	3	13075202.5	767709.678	7803177.69	62853589.8
VAR	23	45299331.3**	448458.146*	5448874.31*	59840283.5*
RXV	69	5365561.4	247587.853	2765006.52	28661477.9
Corrected Total	95	15277199.6	312644.508	3573885.18	37289781.7
Cal. F		8.44	1.81131	1.97	2.087
Prob > F		0.0001	0.0305	0.0162	0.0101
C.V. %		18.20	26.53	20.08	23.58

**Significant at the .01 level.
*Significant at the .05 level.

TABLE II

YIELD OF TOTAL GREEN MATTER FOR TWENTY-THREE VARIETIES
OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Larger to Smaller	Total Green Weight kg/ha
T-876	1	32507.11 a
T-522	2	28847.37 a b
T-131	3	28066.99 a b c
Stafford 208	4	26210.21 a b c d
OK 697947	5	25914.20 a b c d e
Pathfinder	6	24864.71 b c d e
CL 72	7	24810.98 b c d e
Kans. sel	8	24703.25 b c d e
T-385	9	24057.42 b c d e
NB 69150	10	23411.58 b c d e
T-206	11	23169.39 b c d e f
OK 72179	12	22792.66 b c d e f
OK 7111757	13	22604.29 b c d e f
T-419	14	21258.79 c d e f
T-208	15	20666.78 c d e f
T-209	16	20155.49 d e f
OK 72181	17	19751.83 d e f
T 27042-45	18	19671.11 d e f
T-205	19	19617.29 d e f
T-418	20	19402.01 d e f
OK 7111828	21	19186.73 d e f
OK 7111751	22	190252.19 d e f
T-203	23	18648.53 e f
Scout 66	24	15634.63 f

Those means not followed by the same letter are significantly different at P = .05; means followed by the same letter are not significantly different at P = .05.

TABLE III

CORRELATION COEFFICIENTS FOR TOTAL GREEN MATTER, TOTAL DRY MATTER, GRAIN YIELD AND SOME OTHER CHARACTERS FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Total Gr. Matter	1	0.837 **	0.678 **	0.763 **	0.926 **	0.795 **	0.433 *	0.291	0.409 *	0.540**	0.681 **	-0.202	0.544 **	0.317
2. Stem Gr. Matter		1	0.694 **	0.748 **	0.716 **	0.960 **	0.460 *	0.220	0.565 **	0.198	0.630 **	-0.456*	0.443 *	0.081
3. Leaves Gr. Matter			1	0.538 **	0.601 **	0.660 **	0.818 **	0.066	0.335	0.073	0.526 **	-0.087	0.416 *	0.197
4. Spikes Gr. Matter				1	0.802 **	0.800 **	0.366	0.748 **	0.385	0.234	0.433 *	-0.311	0.318	0.002
5. Total Dry Matter					1	0.751 **	0.446 *	0.496 *	0.318	0.030	0.516 **	-0.117	0.386	0.158
6. Stem Dry Matter						1	0.502 **	0.352	0.603 **	0.389	0.501 **	-0.496*	0.288	0.062
7. Leaves Dry Matter							1	0.077	0.138	0.133	0.386	-0.063	0.241	0.008
8. Spikes Dry Matter								1	0.105	0.285	-0.032	-0.018	-0.078	-0.373
9. Grain Yield									1	0.474 *	0.358	-0.689**	0.033	-0.099
10. Tiller No.										1	-0.380	-0.438*	-0.452 *	-0.620**
11. Height											1	-0.173	0.539**	-0.511 **
12. % Protein												1	0.126	0.311
13. First Leaf Area													1	0.733 **
14. Second Leaf Area														1

**Significant at the .01 level.
*Significant at the .05 level.

TABLE IV

GREEN WEIGHT OF STEMS FOR TWENTY-THREE VARIETIES
OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Large to Small	Stem Green Weight kg/ha
T-876	1	19967.12 a
T-522	2	19482.74 a b
T-131	3	17087.76 a b c
Kans. sel	4	16791.75 a b c
T-385	5	16576.47 b c
OK 697947	6	14961.88 c d
OK 72179	7	14773.52 c d
NB 69150	8	14665.88 c d e
T-208	9	12836.00 d e f
OK 7111757	10	12513.09 d e f
OK 72181	11	12513.09 d e f
T-206	12	12459.27 d e f g
CL 72	13	11921.07 d e f g h
Stafford 208	14	11840.34 d e f g h
Pathfinder	15	11436.69 f g h i
T-27042-45	16	10171.93 f g h i
Scout 66	17	10145.02 f g h i
T-418	18	10145.02 f g h i
T-205	19	9714.46 f g h i
T-419	20	9553.00 g h i
OK 7111828	21	9499.19 g h i
T-203	22	8960.99 h i
T-209	23	8934.08 h i
OK 7111751	24	8503.52 i

Those means not followed by the same letter are significantly different at P = .05; means followed by the same letter are not significantly different at P = .05.

(Table III) was found between green stems and grain yield (r = 0.565**). Yield of green stems was negatively correlated with the percent of protein (r = -0.456*). The varieties with high yield of green stems had more grain yield and lower protein.

A significant difference was found in the yield of green leaves among varieties (Table I). The green weight of leaves (kg/ha) for 23 varieties of triticale and one variety of wheat are presented in Table V. (T-522, T-876, T-206, OK 697947, T-131, T-418 and Pathfinder) were in the highest group when evaluated for leaf production. A highly significant correlation (Table III) was found between the weight of green leaves and the height (r = 0.526**). The tall varieties produced more weight of green leaves.

A significant difference was found in the yield of green spikes among the varieties (Table I). The green weight of spikes (kg/ha) for 23 varieties of triticale and one variety of wheat are presented in Table VI. The first ten varieties (T-876, T-206, T-131, Pathfinder, T-27042-45, T-522, Kans sel, OK 72179, T-208 and OK 7111757) fell into the highest yielding group as far as green spike weight was concerned. A significant correlation (Table III) was found between the weight of green spikes and the height (r = 0.433*). Tall varieties produced more weight of green spikes.

Yield of Dry Matter

The analysis of variance for the total dry matter and its three components are presented in Table VII. No significant difference was found among varieties at .05 level of probability (Table VII). The average weight of total dry matter (kg/ha) for 23 varieties of

TABLE V

GREEN WEIGHT OF LEAVES FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Larger to Smaller	Leaves Green Weight kg/ha
T-522	1	2717.89 a
T-876	2	2502.62 a b
T-206	3	2368.07 a b c
OK 697947	4	2314.25 a b c d
T-131	5	2206.61 a b c d e
T-418	6	2098.99 a b c d e f
Pathfinder	7	2072.06 a b c d e f
Kans. sel	8	1910.62 b c d e f
T-385	9	1910.60 b c d e f
T-209	10	1802.96 b c d e f
OK 7111757	11	1802.96 b c d e f
NB 69150	12	1776.05 c d e f
OK 72179	13	1695.33 c d e f
OK 7111828	14	1695.33 c d e f
T-205	15	1695.33 c d e f
T-208	16	1695.33 c d e f
Scout 66	17	1668.41 c d e f
T-203	18	1668.41 c d e f
CL 72	19	1641.59 d e f
OK 72181	20	1641.50 d e f
OK 7111751	21	1641.50 d e f
Stafford 208	22	1587.68 e f
T-27042-45	23	1533.86 e f
T-419	24	1399.31 f

Those means not followed by the same letter are significantly different at P = .05; means followed by the same letter are not significantly different at P = .05.

TABLE VI

GREEN WEIGHT OF SPIKES FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Large to Small	Spike Green Weight kg/ha
T-876	1	10763.94 a
T-206	2	9579.91 a b
T-131	3	9418.45 a b
Pathfinder	4	9310.81 a b
T-27042-45	5	9310.81 a b c
T-522	6	9256.99 a b c
Kans. sel	7	9203.17 a b c d
OK 72179	8	9068.62 a b c d
T-208	9	8745.70 a b c d e
OK 7111757	10	8745.70 a b c d e
OK 697947	11	8691.88 b c d e f
T-385	12	8557.33 b c d e f
Stafford 208	13	8503.52 b c d e f
CL 72	14	8099.87 b c d e f g
NB 69150	15	7992.23 b c d e f g
T-419	16	7911.50 b c d e f g
OK 72181	17	7803.85 b c d e f g
OK 7111828	18	7507.85 b c d e f g
Scout 66	19	7265.66 b c d e f g
T-418	20	6996.57 c d e f g
T-209	21	6888.21 d e f g
OK 7111751	22	6808.20 e f g
T-205	23	6350.70 f g
T-203	24	5973.99 g

Those means not followed by the same letter are significantly different at P = .05; means followed by the same letter are not significantly different at P = .05.

TABLE VII

MEAN SQUARES FOR STEMS, LEAVES, SPIKES AND TOTAL DRY WEIGHT OF TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Source of Variation	d.f.	Dry Weight			
		Stems	Leaves	Spikes	Total
REP	3	334171.15	360230.558	613694.64	4455261.89
VAR	23	4832412.75**	141212.393	1092582.43	6434045.29
RXV	69	789367.17	146190.562	741673.99	5093276.31
Corrected Total	95	1753835.18	151744.479	822589.32	5397735.71
Cal. F		6.1218	0.96595	1.47313	1.26324
Prob. > F		0.0001	0.5175	0.1108	0.2259
C. V. %		17.61	24.67	19.74	20.77

**Significant at the .01 level.

triticale and one variety of wheat are presented in Table VIII. Variable moisture content of varieties probably led to the significant differences observed in total green weight (Table II) since no difference was observed in total dry weight. A highly significant correlation (Table III) was found between the weight of total dry matter and height (r = 0.516**). The taller varieties tended to produce the most dry matter.

A highly significant difference existed among varieties for yield of dry stems (Table VII). The weight of dry stems (kg/ha) for 23 varieties of triticale and one variety of wheat are presented in Table IX. The six highest yielding varieties (T-876, T-522, Kans sel, T-131, T-385 and OK 697947) were not significantly different at .05 level of probability (Table IX). A highly significant correlation (Table III) was found between grain yield and weight of dry stem (r = 0.603**). Yield of dry stem was negatively correlated (Table III) with the percent of protein (r = -0.496*) suggesting that varieties with high yield of dry stems tended to produce more grain yield and contain less protein.

No significant difference existed among varieties for yield of dry leaves (Table VII). The weight of dry leaves (kg/ha) for 23 varieties of triticale and one variety of wheat are presented in Table X. No significant correlation was found between the yield of dry leaves and other characters.

No significant difference existed among varieties for yield of dry spikes (Table VII). The weight of dry spikes (kg/ha) for 23 varieties of triticale and one variety of wheat are presented in Table XI. No

TABLE VIII

YIELD OF DRY MATTER FOR TWENTY-THREE VARIETIES
OF TRITICALE AND ONE VARIETY OF WHEAT

Variety of Name	Rank Larger to Smaller	Total Dry Weight kg/ha
T-876	1	13651.37
T-131	2	12768.73
OK 7111757	3	12513.08
OK 697947	4	12357.00
Stafford 208	5	12184.78
T-522	6	12106.74
Pathfinder	7	11980.30
CL 72	8	11417.90
Kans sel	9	11417.90
T-206	10	11216.02
T-385	11	11070.71
NB 64150	12	10763.95
OK 72179	13	10658.99
T-419	14	10231.13
T 27042-45	15	10171.92
OK 7111751	16	10085.81
T-205	17	10037.40
T-418	18	10013.15
T-208	19	9815.08
OK 7111828	20	9835.55
OK 72181	21	9544.92
T-203	22	9348.48
T-209	23	9082.07
Scout 66	24	8449.69

No significant difference existed between varieties.

TABLE IX

DRY WEIGHT OF STEMS FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Larger to Smaller	Stem Dry Weight kg/ha
T-876	1	7322.18 a
T-522	2	7042.31 a
Kans sel	3	6323.81 a b
T-131	4	6302.29 a b c
T-385	5	6296.91 a b c
OK 697947	6	6202.91 a b c d
NB 69150	7	5677.99 b c d e
OK 72179	8	5538.05 b c d e
T-27042-45	9	5255.49 b c d e
OK 7111757	10	5064.44 c d e f
Stafford 208	11	4956.80 d e f g
T-206	12	4951.42 d e f g
Scout 66	13	4776.50 e f g
OK 72181	14	4776.50 e f g h
Pathfinder	15	4763.05 e f g h
T-208	16	4741.52 e f g h
CL 72	17	4636.57 e f g h
T-418	18	3982.66 f g h
OK 7111828	19	3982.66 f g h
T-205	20	3794.30 g h
T-419	21	3769.39 g h
OK 7111751	22	3713.56 g h
T-203	23	3686.60 h
T-209	24	3552.10 h

Those means not followed by the same letter are significantly different at P = .05; means followed by the same letter are not significantly different at P = .05.

TABLE X

DRY WEIGHT OF LEAVES FOR TWENTY-THREE VARIETIES
OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Larger to Smaller	Leaves Dry Weight kg/ha
OK 697947	1	1961.72
T-522	2	1864.86
T-131	3	1749.14
Pathfinder	4	1738.38
T-206	5	1730.30
T-418	6	1719.55
OK 7111828	7	1681.87
T-876	8	1649.60
Kans sel	9	1622.66
OK 7111757	10	1601.14
Scout 66	11	1587.69
NB 69150	12	1579.60
T-203	13	1493.50
T-385	14	1474.66
T-204	15	1466.60
OK 7111751	16	1453.13
OK 72174	17	1426.22
CL 72	18	1407.39
Stafford 208	19	1391.24
T-27042-45	20	1385.90
OK 72181	21	1380.50
T-208	22	1345.50
T-205	23	1267.46
T-419	24	1224.39

No significant difference existed between varieties.

TABLE IX

DRY WEIGHT OF SPIKES FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Larger to Smaller	Spike Dry Weight kg/ha
T-27042-45	1	5435.79
Pathfinder	2	5260.90
T-206	3	5018.70
OK 7111757	4	4897.59
T-208	5	4870.70
T-876	6	4722.70
T-131	7	4601.60
Kans sel	8	4588.13
Stafford 208	9	4574.70
CL 72	10	4539.70
OK 72179	11	4448.20
T-419	12	4351.40
Scout 66	13	4332.50
OK 697947	14	4286.80
T-385	15	4257.13
OK 72181	16	4208.70
NB 69150	17	4039.20
T-418	18	3961.13
OK 7111828	19	3931.60
OK 7111751	20	3880.40
T-522	21	3858.87
T-203	22	3694.72
T-205	23	3535.95
T-209	24	3404.09

No significant difference existed between varieties.

significant correlation was found between yield of dry spikes and other characters.

Hay Quality

The percent of total dry weight contributed by leaves, stems, and spikes is an indication of hay quality (Table XII). The best quality hay should have a high percentage of leaves and/or spikes and a low percentage of stems. OK 7111828 appears to have the best hay quality. It contains 17.10 percent leaves, 40.49 percent stems, and 42.41 percent spikes on a dry weight basis. T-418 contained slightly more leaves than OK 7111828 but also contained more stems and fewer spikes; therefore, does not appear to be as high in quality. T-205 was good in percentage spikes (45.23 percent); however, it was also low in percentage leaves (12.63 percent). The variety which produced the lowest quality hay was T-876 with 12.08 percent leaves, 53.64 percent stems, and 34.28 percent spikes.

Grain Yield

A highly significant differences was found among varieties for grain production (Table XIII). The weight of grain (kg/ha) for 23 varieties of triticale and one variety of wheat are presented in Table XIV. The two highest yielding varieties were T-876 and Scout 66 wheat. The second high group of varieties (T-522, OK 72181, OK 72179, NB 69150 and Kans sel) are all winter types which are adapted to Oklahoma growing conditions. A highly significant correlation (Table III) was found between grain yield and stem green weight (r = 0.565**). The varieties with high green weight of stems tended

TABLE XII

PERCENTAGE OF THE TOTAL DRY WEIGHT CONTRIBUTED BY EACH OF THE PLANT COMPONENTS FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Leaves	Stem	Spike
OK 697947	15.88	49.20	34.92
T-522	15.40	47.58	37.02
T-131	13.70	49.38	36.92
Pathfinder	14.51	41.58	43.91
T-206	15.43	44.15	40.42
T-418	17.17	42.77	40.06
OK 7111828	17.10	40.49	42.41
T-876	12.08	53.64	34.28
Kans sel	14.21	45.39	40.40
OK 7111757	14.80	42.47	42.73
Scout 66	11.79	47.53	34.68
NB 69150	13.27	48.21	38.52
T-203	15.91	45.44	38.65
T-385	13.32	51.24	35.44
T-209	16.15	46.37	37.48
OK 7111751	15.41	41.89	42.70
OK 72179	13.38	45.80	40.82
CL 72	14.33	45.61	40.06
Stafford 208	13.42	43.68	42.90
T 27042-45	13.62	48.90	37.48
OK 72181	13.46	46.04	40.50
T-208	13.63	42.61	43.76
T-205	12.63	42.14	45.23
T-419	12.97	46.82	40.21

No significant difference existed between varieties.

TABLE XIII

MEAN SQUARES FOR GRAIN YIELD, NUMBER OF TILLERS, HEIGHT, PERCENT PROTEIN, AND FIRST AND SECOND LEAF AREA FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Source of Variation	d.f.	Grain Yield	Number Tillers	Height	Protein %	Leaf 1 Area	Leaf 2 Area
REP	3	5275.10720	116.45833	325.5833	0.2884375	105.6645	224.3535
VAR	23	7817.02179**	607.085145**	269.8840**	1.65441576**	26.6725	39.09226
RXV	69	1765.16210	56.530797	60.51811	0.65756793	15.9549	26.56472
Corrected total	95	3341.1895	191.715351	119.57719	0.88725329	21.3826	35.84366
Cal. F		4.4285	10.73902	4.45956	2.51596	1.67175	1.47159
Prob. > F		0.0001	0.0001	0.0001	0.002	0.0528	0.1115
C. V. %		18.70	17.95	7.41	8.27	25.29	28.05

**Significant at the .01 level.

TABLE XIV

YIELD OF GRAIN FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Larger to Smaller	Grain Yield kg/ha
T-876	1	2394.10 a
Scout 66	2	2035.93 a b
T-522	3	1837.94 b c
OK 72181	4	1762.53 b c d
OK 72179	5	1734.27 b c d e
NB 69150	6	1649.51 b c d e f
Kans sel	7	1649.51 b c d e f
T-131	8	1564.81 c d e f g
Pathfinder	9	1564.81 c d e f g
CL 72	10	1555.26 c d e f g h
T-205	11	1517.72 c d e f g h i
T-203	12	1498.88 c d e f g h i j
T 27042-45	13	1470.62 c d e f g h i j
OK 697947	14	1432.68 c d e f g h i j
Stafford 205	15	1376.44 d e f g h i j
T-385	16	1375.60 e f g h i j
OK 7111751	17	1357.60 e f g h i j
OK 7111757	18	1300.69 f g h i j
OK 7111828	19	1300.69 f g h i j
T-206	20	1263.42 f g h i j
T-208	21	1235.16 g h i j
T-209	22	1159.34 h i j
T-419	23	1149.93 i j
T-418	24	1112.18 j

Those means not followed by the same letter are significantly different at P = .05; means followed by the same letter are not significantly different at P = .05.

to produce more grain yield. A significant correlation (Table III) was found between grain yield and tiller number (r = 0.474*). The varieties with more tillers tended to produce more grain yield.

Tillering Ability

A highly significant difference was found among varieties for tillers number (Table XIII). The average number of tillers per square foot for 23 varieties of triticale and one variety of wheat are presented in Table XV. Scout 66 recorded the highest number of tillers per square foot. T-27042-45 ranked second in number of tillers; however, it ranked thirteenth in grain yield. T-876 ranked fourth for number of tillers; however, it ranked first in grain yield. The number of tillers was negatively correlated (Table III) to percent of protein (r = -0.438*). The varieties with high number of tillers had lower percent of protein.

Height

A highly significant difference was found among varieties for plant height (Table XIII). The average height in centimeters for 23 varieties of triticale and one variety of wheat are presented in Table XVI. T-876, OK 72179, T-522, OK 697947, and OK 7111828 were the tall varieties with no significant difference among themselves. The two short varieties were Scout 66 and T-27042-45. A highly significant correlation (Table III) was found between height and total green matter (r = 0.681**). The taller varieties tended to produce more green matter.

TABLE XV

NUMBER OF TILLERS PER SQUARE FOOT FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Larger to Smaller	No. of Spikes per Square Foot
Scout 66	1	83 a
T 27042-45	2	67 b
T-385	3	51 c
T-876	4	48 c d
NB 69150	5	47 c d e
Kans sel	6	46 c d e
T-131	7	44 c d e f
T-418	8	44 c d e f
T-522	9	44 c d e f
Stafford 208	10	42 c d e f g
T-206	11	42 c d e f g
OK 697947	12	40 d e f g
OK 72179	13	40 d e f g h
OK 72181	14	38 d e f g h i
CL 72	15	37 f g h i
OK 7111757	16	35 g h i
T-205	17	34 g h i
Pathfinder	18	33 g h i
T-209	19	32 g h i
T-419	20	32 g h i
OK 7111751	21	31 h i
T-208	22	29 i
T-203	23	29 i
OK 7111828	24	29 i

Those means not followed by the same letter are significantly different at P = .05; means followed by the same letter are not significantly different at P = .05.

TABLE XVI

HEIGHT IN CENTIMETER FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Larger to Smaller	Height cm
T-876	1	122.00 a
OK 72179	2	115.00 a
T-522	3	115.00 a b
OK 697947	4	113.75 a b c
OK 7111828	5	112.50 a b c d e
Pathfinder	6	109.25 b c d e
Stafford 208	7	108.00 b c d e f
CL 72	8	107.50 b c d e f
OK 7111757	9	107.50 b c d e f
T-208	10	107.50 b c d e f
Kans sel	11	107.00 b c d e f g
OK 72181	12	106.25 b c d e f g
T-131	13	105.50 b c d e f g
T-385	14	105.50 b c d e f g
T-205	15	103.75 c d e f g h
T-206	16	101.75 d e f g h
NB 69150	17	100.75 e f g h
T-209	18	100.75 f g h
T-418	19	100.00 f g h
T-203	20	98.75 f g h
OK 7111751	21	98.25 f g h
T-419	22	97.00 h
Scout 66	23	93.00 h i
T 27042-45	24	82.50 i

Those means not followed by the same letter are significantly different at P = .05; means followed by the same letter are not significantly different at P = .05.

TABLE XVII

PERCENT PROTEIN FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Larger to Smaller	Protein Content %
T-209	1	10.97 a
OK 7111757	2	10.87 a b
T-205	3	10.70 a b c
T-418	4	10.65 a b c d
OK 7111828	5	10.27 a b c d e
T-206	6	10.22 a b c d e
Pathfinder	7	10.13 a b c d e f
T-419	8	10.10 a b c d e f
T-203	9	10.02 a b c d e f
T 27042-45	10	10.02 a b c d e f g
T-385	11	9.83 a b c d e f g
Stafford 208	12	9.83 a b c d e f g
CL 72	13	9.80 b c d e f g h
OK 7111751	14	9.70 c d e f g h
T-522	15	9.65 c d e f g h
OK 72179	16	9.62 c d e f g h i
Kans sel	17	9.52 d e f g h i
OK 697947	18	9.47 e f g h i
T-131	19	9.45 e f g h i
NB 69150	20	9.20 e f g h i
T-208	21	9.15 f g h i
T-876	22	8.90 g h i
OK 72181	23	8.72 h i
Scout 66	24	8.55 i

Those means not followed by the same letter are significantly different at P = .05; means followed by the same letter are not significantly different at P = .05.

Protein Content

A highly significant difference was found among varieties for percent protein (Table XIII). The average percent protein for 23 varieties of triticale and one variety of wheat are presented in Table XVII. Scout 66 ranked last in percent protein. T-876 which ranked first in grain yield ranked twenty-second (in the lowest group) in percent protein. A highly negative correlation (Table III) was found between percent protein and grain yield (r = -0.689**), suggesting that varieties with high grain yield contained less protein.

First Leaf Area

The differences among varieties for first leaf area was not significant at .05 level of probability (Table XIII). The average first leaf area for 23 varieties of triticale and one variety of wheat are presented in Table XVIII. A highly significant correlation (Table III) was found between first leaf area and total green matter (r = 0.544**) and height (r = 0.539**). The varieties with large first leaf area tended to produce more total green matter.

Second Leaf Area

The differences among varieties for the second leaf area was not significant at .05 level of probability (Table XIII). The average second leaf area for 23 varieties of triticale and one variety of wheat are presented in Table XIX. No important correlation between second leaf area and other character was observed.

TABLE XVIII

FIRST LEAF AREA FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Larger to Smaller	Leaf Area for First Leaf Square CM
T-522	1	19.70
CL-72	2	19.65
OK 7111757	3	18.60
Kans sel	4	18.54
T-876	5	18.44
T-206	6	18.32
NB 69150	7	17.90
T-209	8	17.70
T-131	9	16.60
OK 7111828	10	16.60
OK 72181	11	16.50
T-208	12	15.60
T-419	13	15.40
OK 697947	14	15.30
OK 72179	15	15.02
OK 7111751	16	15.00
T-205	17	14.90
T-418	18	14.86
Stafford 208	19	14.40
Pathfinder	20	13.70
T-385	21	13.03
T-203	22	12.97
T-27042-45	23	11.45
Scout 66	24	9.40

No significant difference existed between varieties.

TABLE XIX

SECOND LEAF AREA FOR TWENTY-THREE VARIETIES OF TRITICALE AND ONE VARIETY OF WHEAT

Name of Variety	Rank Larger to Smaller	Leaf Area for Second Leaf Square CM
T-209	1	24.70
CL 72	2	22.02
T-522	3	21.71
T-876	4	21.60
OK 7111828	5	21.53
OK 7111751	6	20.80
OK 72181	7	19.83
T-205	8	19.68
T-206	9	19.37
OK 72179	10	19.32
OK 697947	11	19.07
Stafford 208	12	18.90
T-419	13	18.50
NB 69150	14	18.31
OK 7111757	15	18.18
Kans sel	16	17.26
T-418	17	17.13
Pathfinder	18	17.05
T-208	19	16.50
T-385	20	16.10
T-203	21	15.00
T-131	22	14.99
T-27042-45	23	13.70
Scout 66	24	10.00

No significant difference existed between varieties.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was conducted on the Triticale Performance Nursery, grown at the Agronomy Research Station, Stillwater, Oklahoma. The nursery consisted of twenty-three triticale varieties and one variety of wheat (Scout 66) which was included as a check variety. The objectives of this study were (1) to determine which existing varieties of triticale adapted to Oklahoma will produce the greatest yield and best quality of hay, (2) to determine which existing varieties of triticale adapted to Oklahoma will produce the greatest yield of grain, and (3) to determine the agronomic characteristics of the triticale varieties under Oklahoma conditions. The characters evaluated were hay yields, grain yields, tiller number, plant height, protein content and leaf area. The varieties were planted in a randomized complete block design with four replications. Each plot consisted of four rows, ten feet long. Statistical analyses were carried out on all the traits. The analyses of variance showed that varieties were different for all the characters studied except the total dry matter, leaves dry matter, spikes dry matter and first and second leaf areas.

T-876, T-522, T-131, Stafford 208, and OK 697947 were in the highest yielding group in total green weight. Even though there was no significant difference in total dry weight, these same five varieties were among the top six entries. However, all of these top yielding varieties were inferior for hay quality. Stafford 208 with 13.42 percent leaves, 43.68 percent stems, and 42.90 percent spikes appears to have the best quality among this high yielding group. This variety also exhibited the best protein percentage (9.83%) of the high yielding group.

OK 711828, Pathfinder, OK 7111751, T-205, OK 7111757, and T-418 produced the highest quality hay since they contained a high percentage of leaves and spikes and a low percentage of stems. Also, all of these entries except OK 7111751 were in the highest group in protein percentage. However, all except Pathfinder were in the lower half of the nursery in yield of total green weight. Pathfinder ranked sixth in total green weight.

The data indicate that the varieties with the highest forage yields had relatively poor forage quality. The varieties with good forage yields had relatively poor forage quality. The varieties with good forage quality had relatively poor forage yields.

The positive correlation between height and total green weight should be useful to the plant breeder who is interested in increasing forage yields. He should be able to select taller types to increase forage yields. However, this could decrease forage quality. Since stem weights (both green and dry) are highly correlated with total forage production, the breeder may be unable to substantially increase total forage yield and forage quality at the same time.

A highly significant difference existed among varieties for grain yield. T-876 and Scout 66 wheat were in the highest group in grain yield. T-876 was also the highest yielding variety in forage production; however, it was the poorest variety in forage quality with 12.08%

leaves, 53.64% stems, and 34.28% spikes, and 8.90% protein. T-522 ranked third in grain yield and was in the second highest group. It also was in the highest group for forage production and was relatively poor in forage quality. Both of these varieties are winter types and are relatively late in maturity.

Highly significant positive correlations were observed between grain yield and stem weights (both green and dry). Significant positive correlations were observed between grain yield and total green weight and between grain yield and tiller number. Grain yield was negatively correlated with percent protein.

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