THE EFFECTS OF SWATHING ON THE MALTING QUALITY OF WINTER BARLEY LINES GROWN IN OKLAHOMA

By

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GROWN IN OKLAHOMA

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CHAPTER I

INTRODUCTION

Barley is one of the most ancient plants utilized by man. Barley was once considered to be the gift to man from Ceres, Roman goddess of agriculture. It is grown extensively throughout the world wherever temperature, moisture, and soil are conducive to its economic cultivation. Barley ranks fourth in the United States in importance among the cereal grain crops, being exceeded by corn, wheat, and oats. Barley is an unique grain crop from the standpoint of being able to mature in a shorter season than any other major cereal grain.

Barley grown in the United States is divided into two major types, spring and winter. Spring barley is grown in the north central plains and Pacific northwest. Winter barley is cultivated mainly in the southern one half of the United States. Spring barleys have been used almost exclusively for malting purposes. Winter barley is less winter-hardy than winter wheat or winter rye but more hardy than winter oats.

Two major uses, livestock feed and malting, consume the majority of the barley produced in the United States. High quality malting barley generally implies that the grain is bright in color, uniform in kernel size, and intermediate in protein content. Barley which meets these requirements produce high yields of malt during the malting process. The malting process is essentially the conversion of the starch to sugar in the grain by induced germination. Brewing, which follows, is a yeast fermentation wherein sugars are converted to alcohol.

In recent years, leaders in the malting industry have encouraged research on the production of malting barley in the Southern Great Plains. The objectives of this study are to determine the effects of swathing and genotype on the quality of winter barley grown in the Oklahoma Panhandle, and to determine the kernel moisture content range at which barley can be swathed without loss in quality or yield. The preparation of the manuscript is in a form acceptable to the Crop Science Society of America.[1/] The same format is currently being adopted by many professional journals. Additional data pertaining to the study are presented in tabular form in the Appendix.

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[1]Handbook and Style Manual for ASA, CSSA, and SSSA Publications, (1976).

CHAPTER II

ABSTRACT[1]

Twenty-two winter barley lines were swathed at four moisture levels to determine the effects of swathing on malting quality in an irrigated environment at Goodwell, Oklahoma, in 1975-1976. Swathing level one was harvested when the kernel moisture content was 25 to 30%. Swathing levels two, three, and four were harvested on consecutive two-day intervals after level one. A split-plot design was used to study the effects of swathing and genotypes on grain yield, kernel protein, and percent thin kernels. Main-plots were barley lines and sub-plots were swathing levels. Seed was bulked within swathing levels and across replications to obtain the required sample size for laboratory malting. A randomized complete-block, where blocks equaled barley lines and treatments equaled swathing levels, was used to analyze the effects of swathing on percent plump kernels, 1000-kernel weight, kernel color (Agtron), percent malt extract, percent fine-course difference, wort color, percent barley nitrogen, percent wort nitrogen, wort nitrogen/malt nitrogen ratio, diastatic power (Deg), and alpha amylase (20 degree units).

Swathing malting barley at a kernel moisture content of 25 to 30% was found to have significant effects on grain yield, percent plump kernels, percent fine-course difference, percent wort nitrogen, and

[1]To be submitted for publication.

alpha amylase. An increase in grain yield of 1307.84 ka/ha and an improvement in percent wort nitrogen by a reduction of .03% was observed at swathing level one compared to level four. Deleterious effects on malting quality of swathing at level one were a decrease of 4.69% plump kernels, an increase of .41% fine-course difference, a decrease of .78% wort nitrogen/malt nitrogen ratio, and a decrease of 1.36 units alpha amylase. Alpha amylase was the only character reduced below malting quality requirements by swathing at a kernel moisture content of 25 to 30%.

CHAPTER III

LITERATURE REVIEW

Barley (*Hordeum vulgare* L.) is grown primarily for feed or malting purposes. An increased demand by the malting industry has led to the production of malting quality barley in new areas. The Oklahoma Panhandle, where winter barley is grown under irrigated conditions, is potentially one of these areas.

Important characteristics of a malting barley are medium to large, uniform kernels, medium to low protein, medium to high diastatic power, and high extract (1). The effects of cultural practices on these characters in new environments must be determined. Swathing of malting barley offers the producer two advantages. In a double-cropping system, swathing permits the barley crop to be removed from the field one to two weeks earlier. Harvesting earlier may also eliminate hazards due to damaging weather late in the growing season.

The kernel moisture content (KMC) range at which barley can be swathed without loss of quality or yield may change in different environments. Harlan (7) found barley kernels to be fully mature when the moisture reached 46% and only a limited amount of translocation to the spike had occurred for some time. Brewer and Poehlman (4), working with winter barley in Missouri, observed significant differences in grain yield, 1000-kernel weight, test weight, and kernel size but not in Agtron color or nitrogen content of kernels harvested at KMC ranges of 48.5 to 9.8% and 54.3 to 10.1%. They concluded that swathing may safely be done when the KMC has reached about 40% without loss in grain yield, 1000-kernel weight, test weight, or kernel nitrogen.

McLean (10) found significantly lower yields from plots of 'O.A.C. 21' barley harvested 19, 16, and 12 days before maturity but not 9, 5, and 3 days. In this study no significant reduction in either yield or 1000-kernel weight resulted from harvesting one week before maturity, but slight increases of kernel nitrogen was noted up to four days past maturity. Koenig et al. (9) swathed 'Movarin' barley at a KMC range from 50% to maturity and found no significant changes for yield or protein although kernel nitrogen increased as the grain matured. A 20% increase of large kernels was obtained by harvesting at a KMC of 18% rather than at 42%. Koenig concluded that under Colorado conditions barley can be swathed without any appreciable loss in quality when the KMC is below 25%.

Total nitrogen content, extract, and enzyme activity increased as KMC decreased in a study reported by Dew and Bendelow (6) who worked with 'Parkland' and 'Husky' cultivars. They stated that varietal differences were apparent although the variation in the properties of each cultivar with KMC was the same. Harris and Banasik (8) worked with five barley cultivars and found the cultivar to have a highly significant effect on nitrogen content, diastatic power and extract. Anderson and Sallans (2) analyzed 12 cultivars grown at 12 stations in Canada and found a definite indication that cultivars which tend to show high enzyme activity with respect to one enzyme also tend to show high activities with respect to other enzymes.

Bendelow and Meredith (3) analyzed 243 barley lines and found the efficiency of predicting malting quality for one line from one year to the next was 79% effective. This indicated that year-to-year fluctuations in malting quality are consistent within varieties. Den Hartog and Lambert (5) studied 10 crosses with 'Mars' as a common parent. They stated that significant differences existed between crosses and between lines within a cross for average kernel weight, general fertility, bushel weight, yield, protein, extract and diastatic power.

CHAPTER IV

MATERIALS AND METHODS

Twenty-two winter barley cultivars were planted 22 October, 1975 at the Panhandle Experiment Station, Goodwell, Oklahoma. The twenty-two cultivars consisted of 10 advanced Oklahoma selections, 8 advanced Idaho selections, and 4 check varieties and were grown in a malting barley yield nursery (Table I). The soil type was a Richland Clay Loam. The test area was summer fallowed and no crop was produced the previous year. In February 112 kg/ha was top dressed in the form of NH_4NO_3. The test received 11.21 cm rainfall during the growing season. One pre-plant plus four post-emergence irrigations were applied during the crop year. Approximately 3.6 cm/ha of water was applied per irrigation for a total of 18 cm/ha.

Each genotype was replicated three times. Each plot consisted of four rows three meters in length and 30 cm apart, seeded at 67.29 kg/ha. The two outside rows served as guard rows. The two center rows were divided in half lengthwise to give four sub-plots, each one row and 1.5 meters in length. The barley of each sub-plot from each plot was cut and shocked at one of four moisture levels. To simulate swathing each sub-plot was cut by hand and the harvested material shocked to dry. Swathing level one was cut when the KMC was 25 to 30%. Kernel moisture content was determined with a Burrows Digital Moisture Computer 700. Swathing levels two, three, and four were cut on consecutive two-day intervals after level one. Kernel moisture content at swathing level four was considered normal for harvesting by combine in this area. The shocks were allowed to stand in the field to dry. Average drying period was two days. Samples were threshed with a Vogel thresher after the drying period. Average daily high temperatures during the swathing periods was 32^{o} C. Rainfall during the swathing period was .2 cm.

A split plot analysis was used to study the effects of swathing and genotype on grain yield, percent kernel protein, and percent thin kernels. The determinations were made at the Oklahoma Agricultural Experiment Station. Main-plots were barley lines and sub-plots were swathing levels. Grain yield was found by weighing the total threshed, cleaned grain from each sub-plot. Percent kernel protein for each sub-plot was analyzed using the Udy method. Eighteen samples were selected that represented the total Udy range. The protein content of these samples was determined by the Kjeldhal procedure with a 6.25 x N factor. Udy readings were converted to Kjeldhal protein by calculating a simple correlation. The correlation coefficient was .81. Percent thin kernels was determined for each sub-plot with a Dean Gamet Model M109 Ratiomotor. Percent thin kernels equaled the percentage of kernels from a 100 g sample passing through a 5/64 x 3/4 in. seive after 210 (3 minutes) oscillations.

Grain was bulked within swathing levels and across replications to obtain the required sample size for laboratory malting. A 200 g sample consisted of a representative amount of grain from each replication, one cultivar, and one swathing level. A randomized complete-block, where blocks equaled cultivars and treatments equaled swathing levels, was used to analyze the effects of swathing on 1000-kernel weight, percent plump kernels, kernel color (Agtron), percent malt nitrogen, percent fine-course difference, wort color, percent wort nitrogen, wort nitrogen/malt nitrogen ratio, diastatic power (Deg), and alpha amylase (20^{o} units). Laboratory analyses for these characters were done by the Federal Barley and Malt Laboratory at Madison, Wisconsin. Statistical analyses for all characters were completed in the University Computer Center, Oklahoma State University, Stillwater, Oklahoma.

CHAPTER V

RESULTS AND DISCUSSION

Means and observed significance levels for swathing effects are shown in Table II. Mean squares and observed significance levels (Table III) for characters in the split-plot design indicate no significant effects of swathing at the four moisture levels on percent kernel protein or percent thin kernels at .05 significance level. Highly significant swathing effects were found for grain yield. As the grain dried from swathing level one to level four, a decrease in yield of 1307.84 kg/ha was observed. Figure 1 illustrates this decrease in yield. Significant increases in yield by swathing was also found by Brewer and Phoehlman (4) but not by McLean (10) or Koenig et al. (9). Our observed reduction in yield probably resulted from grain shatter and lodging prior to harvest. Grain shattering probably had the greatest effect because of the climatic conditions such as high winds, high temperatures, and low humidity which existed during maturation. The significant swathing x cultivar interaction for kernel protein suggests that cultivars reacted differently to swathing. Cultivars were found to be highly significant for all three characters, which agrees with the findings of Den Hartog and Lambert (5).

Significant swathing effects were found for percent plump kernels, percent fine-course difference, percent wort nitrogen, and alpha amylase. An increase in plump kernels of 4.69% was obtained by swathing at level four rather than level one (Table II). Figure 2 illustrates this trend. Maltsters require a minimum of 25 to 30% plump kernels. Minimum percent plump kernels obtained here at all swathing levels exceeds these requirements. A decrease of .41% was found at level four compared to level one. Figure 3 illustrates this relationship. The most desirable percent fine-course difference was observed at level four, 3.33%. To meet the requirements of a malting barley the fine-course difference should be less than 2%. Only one of the 22 cultivars grown, entry number 15, met this requirement. An increase in wort nitrogen of .03% was found at level four over level one. Figure 4 illustrates this trend. Whether or not this change is practically significant to the maltster depends on the desired properties of the end product. An increase in the wort nitrogen/malt nitrogen ratio of .78% was shown at level four compared to level one. Figure 5 illustrates this change. The lower the wort nitrogen/malt nitrogen ratio the less soluble protein is lost between the malt stage and the wort. A high wort nitrogen/malt nitrogen ratio is desirable for most American beers. Swathing at level one KMC produced an undesirable effect on malting quality. An increase of 1.36 units alpha amylase was observed at swathing level four compared to level one. Figure 6 illustrates this change due to swathing. Minimum alpha amylase required of a malting barley is 30 units. The only swathing level found to meet the requirements was level four. Ten cultivars tested met this requirement. In these ten cultivars an increase in alpha amylase was found as the grain dried before swathing.

1000-kernel weight, kernel color, and diastatic power were not significantly affected by swathing. Although not significant, desirable effects of swathing were shown at level one for kernel color and diastatic power. Undesirable effects resulted from swathing at level one were found for 1000-kernel weight, percent malt extract, and wort color. Cultivars were found to be significant for all characters. Similar results were reported by Harris and Banasik (8) and Den Hartog and Lambert (5).

Overall effects of swathing at a KMC of 25 to 30% were an increase in grain yield of 1307.84 kg/ha, a decrease in plump kernels of 4.69%, an increase in fine-course difference of .41%, a decrease of .03% wort nitrogen, a decrease of the wort nitrogen/malt nitrogen ratio of .78%, and a decrease of alpha amylase content by 1.36 units. These changes represent improvements in grain yield and wort nitrogen; however, swathing reduced quality as far as percent plump kernels, fine-course difference, wort nitrogen/malt nitrogen ratio, and alpha amylase were concerned. However, only alpha amylase was reduced in quality below acceptable malting requirements. The information obtained in this study indicates that swathing malting barley in this environment has the potential to become a practical cultural practice.

TABLE I

CULTIVARS AND LINES GROWN IN THE MALTING BARLEY YIELD NURSERY, GOODWELL, OKLAHOMA, 1976

Entry No.	Cultivar or Pedigree	C.I. or Selection Number	Number Spike Rows	Origin
1	Mich-62-449-22		6	Michigan
2	NY6005-18		6	New York
3	MsTrophy/Will	OK7338204	6	Oklahoma
4	67x1D/Dickson	OK7337708	6	Oklahoma
5	67x1D/Dickson	OK7337733	6	Oklahoma
6	MsTrophy/Will	OK7338172	6	Oklahoma
7	Kerr	11664	6	Oklahoma
8	Kirmse 5/Cordova//Kerr	OK7338003	2	Oklahoma
9	Kirmse 5/Cordova//Kerr	OK7338071	2	Oklahoma
10	MsTrophy/Harrison	OK7338087	6	Oklahoma
11	MsTrophy/Harrison	OK7338125	6	Oklahoma
12	MsTrophy/Will	OK7338185	6	Oklahoma
13	MsTrophy/Will	OK7430254	6	Oklahoma
14	Mo. B2126		2	Missouri
15	63AB2961/Ione	72AB58	6	Idaho
16	63AB2961/Ione	72AB250	6	Idaho
17	63AB2961/Ione	73AB116	6	Idaho
18	63AB2961/Ione	73AB137	6	Idaho
19	63AB2987/Ione	73AB66	6	Idaho
20	63AB2987/Ione	73AB48	6	Idaho
21	63AB2987/Ione	72AB334	6	Idaho
22	Wade/Luther	72AB265	6	Idaho

TABLE II

MEANS AND OBSERVED SIGNIFICANCE LEVELS FOR MALTING CHARACTERS AT FOUR SWATHING LEVELS

Character	Swathing Levels 1	2	3	4	OSL† Swathing	Effect on‡ Malting Quality
Grain yield (kg/ha)	5156.08	4629.76	4383.91	3848.24	.0001	+
% Kernel protein	13.66	13.77	13.75	13.80	.5768	+
% Thin kernels	14.11	14.22	14.28	14.48	.9772	+
% Plump kernels	43.18	44.74	44.72	47.87	.0051	-
1000-Kernel weight (g)	30.03	30.65	30.45	30.50	.1708	-
Kernel color (Agtron)	53.45	54.00	53.54	56.54	.0809	+
% Malt extract	72.96	73.60	73.05	73.15	.7138	-
% Fine-Course difference	3.74	3.62	3.69	3.33	.0134	-
Wort color	2.17	2.17	2.15	2.13	.3572	-
% Wort Nitrogen	.62	.63	.64	.65	.0001	+
Wort N/malt N ratio	28.19	28.71	28.78	28.97	.0297	-
Diastatic power (Deg)	160.27	158.27	155.68	156.63	.5336	+
Alpha amylase	28.74	29.04	29.67	30.10	.0311	-

†Probability of >F if factor listed in column head had no effect
‡+ = positive effect of swathing at level one, - = negative effect of swathing at level one verses four

TABLE III

MEAN SQUARES AND OBSERVED SIGNIFICANCE LEVELS FOR CHARACTERS IN SPLIT-PLOT DESIGN

	Mean Squares				
Character	Variety	Swathing	Variety x Swathing	Error A[‡]	Error B[§]
Grain yield (kg/ha)	11242.3 (.0006)[†]	26991.1 (.0001)	2915.4 (.2952)	3312.8	2610.4
% Kernel protein	4.9 (.0001)	.22 (.5768)	.34 (.0268)	.92	.23
% Thin kernels	1041.4 (.0001)	1.6 (.9772)	29.5 (.2181)	84.2	25.1

[†]Observed significance level
[‡]Error mean square for testing significance of variety
[§]Error mean square for testing significance of swathing and variety x swathing

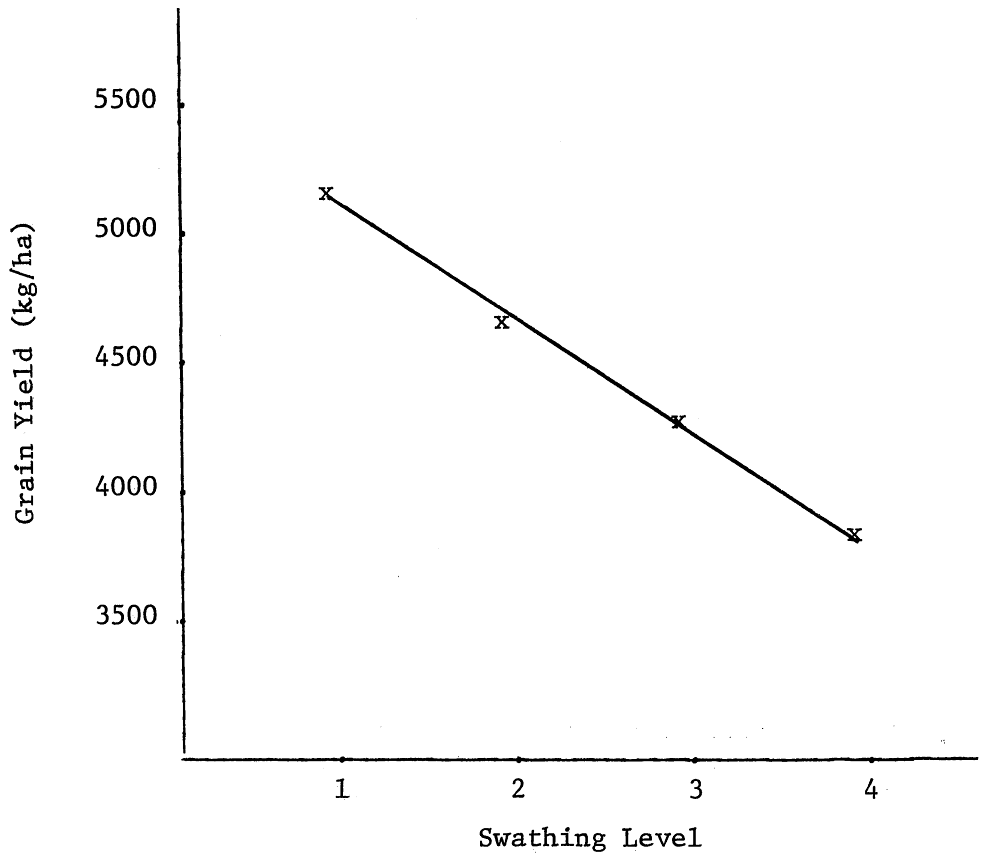

Figure 1. Effects of Swathing on Grain Yield

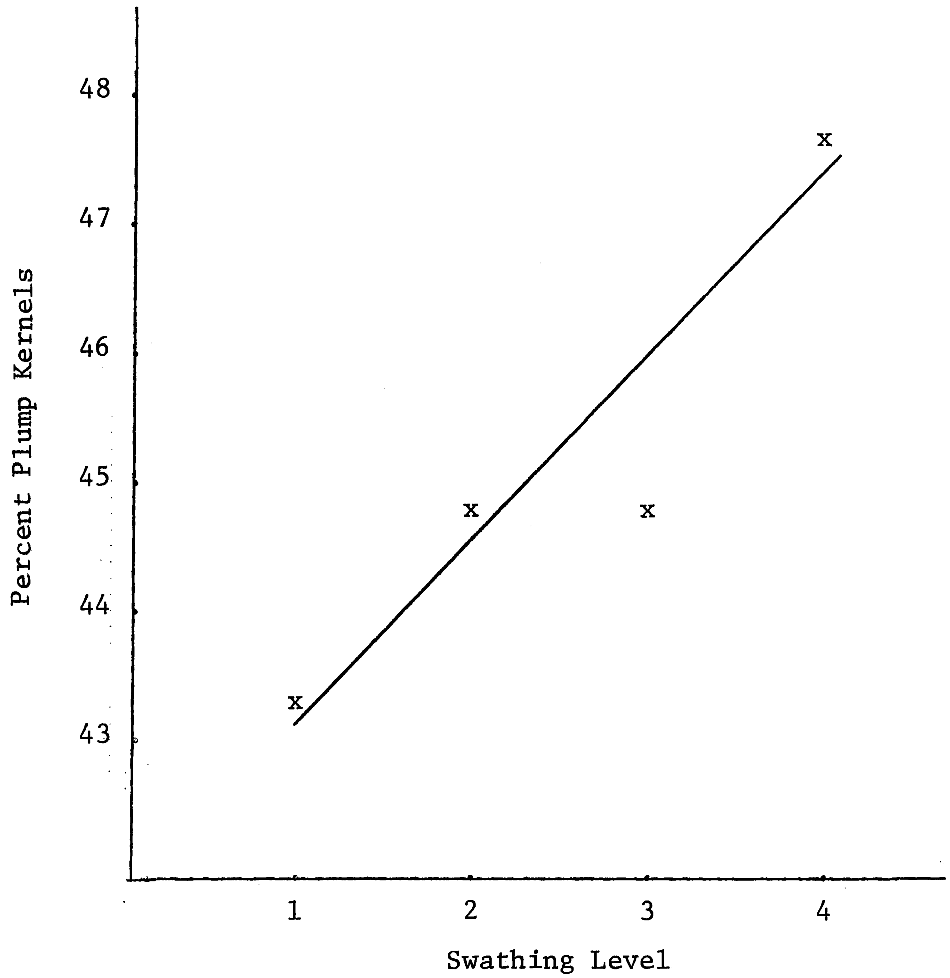

Figure 2. Effects of Swathing on Percent Plump Kernels

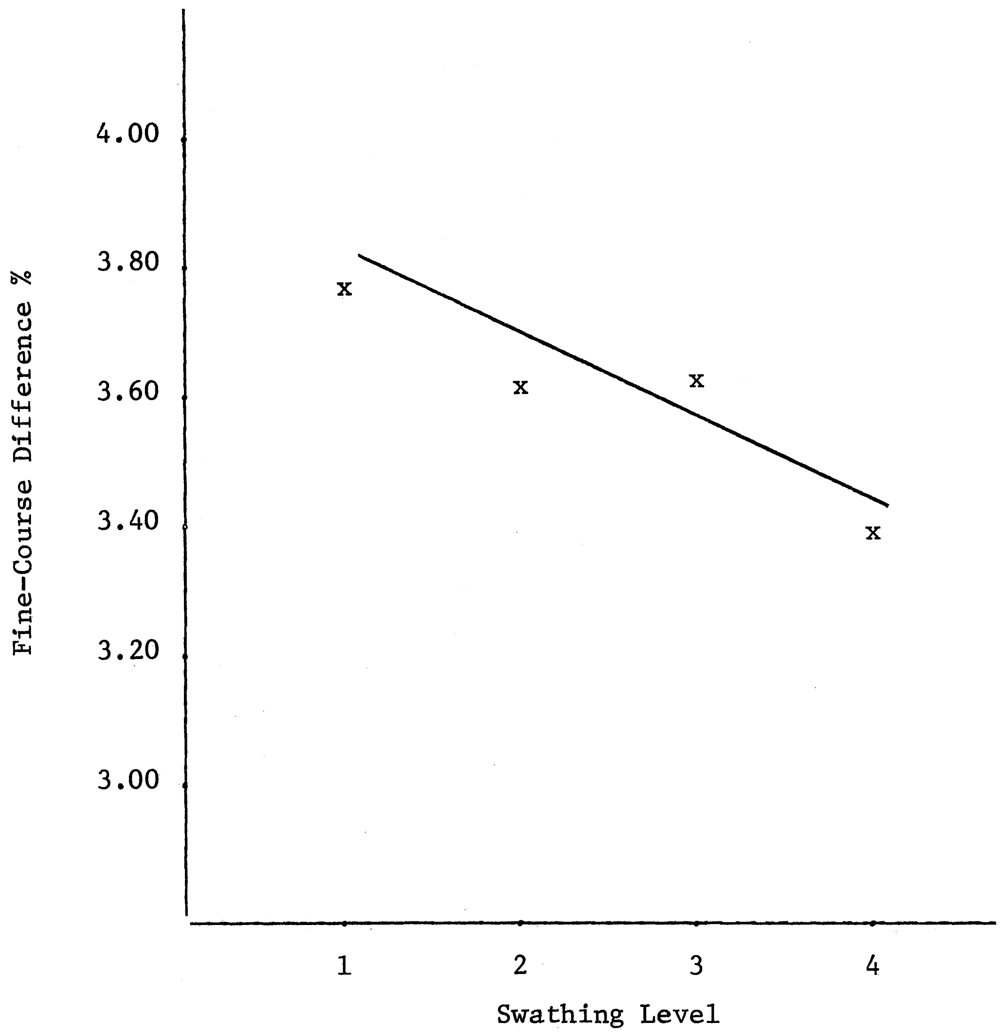

Figure 3. Effects of Swathing on Fine-Course Difference %

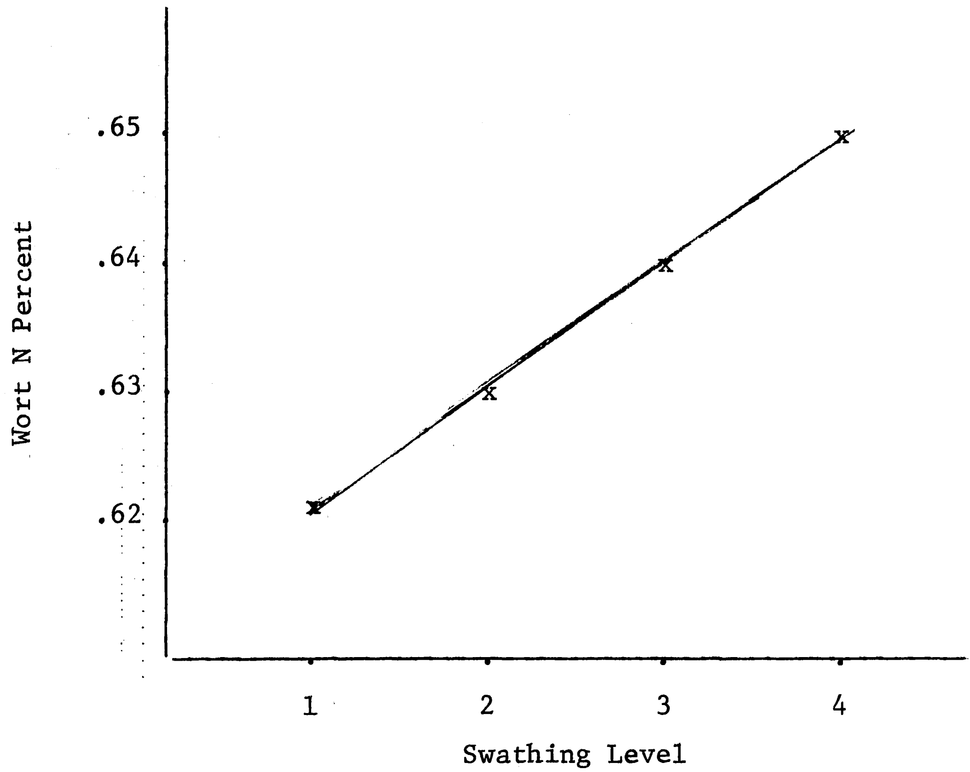

Figure 4. Effects of Swathing on Wort Nitrogen Percent

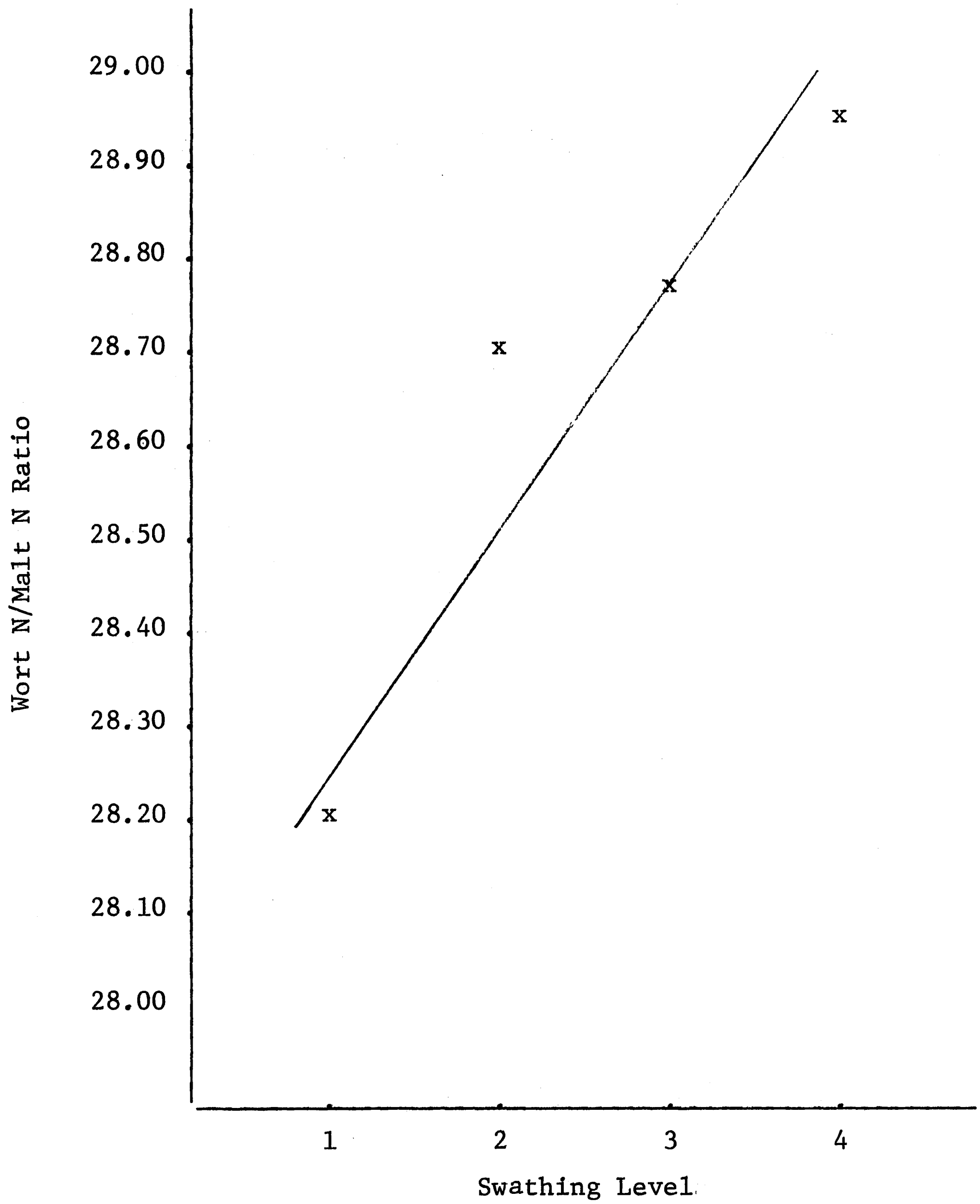

Figure 5. Effects of Swathing on Wort N/Malt N Ratio

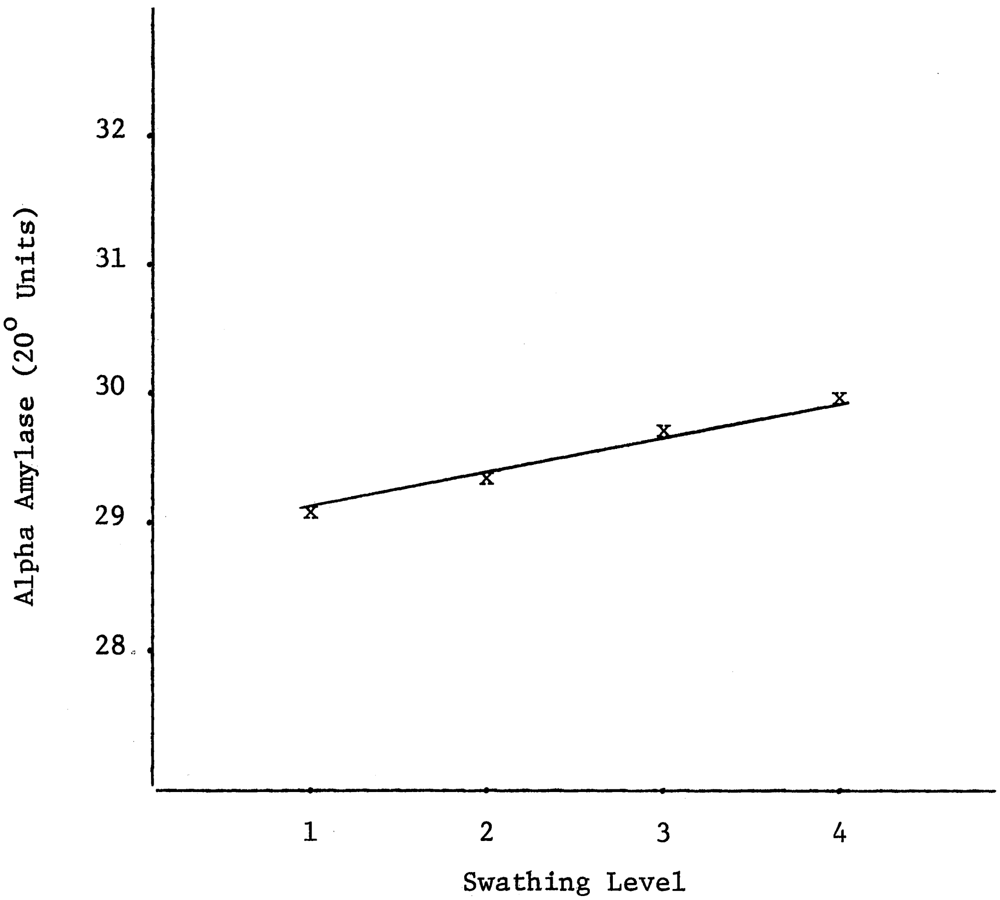

Figure 6. Effects of Swathing on Alpha Amylase

LITERATURE CITED

1. Anderson, J. A., W. O. S. Meredith, and H. R. Sallans. 1943. Malting quality of Canadian barleys IV. Sci. Agric. 23:297-314.

2. Anderson, J. A., and H. R. Sallans. 1955. Varietial differances in barley and malts XII Summary of correlations between 18 major barley, malt, and malting properties. Can. J. Res. 19 sec. C 278-291.

3. Bendelow, V. M., and W. O. Meredith. 1955. Reliability of predication test for malting quality of barley. Can. J. Agric. Sci. 35:252-58.

4. Brewer, D. H., and J. M. Poehlman. 1968. Grain yield and kernel quality of winter barley harvested at different moisture levels. Agron. J. 60:472-74.

5. Den Hartog, G. T., and J. W. Lambert. 1953. The relationships between certain agronomic and malting quality characters of barley. Agron. J. 45:208-12.

6. Dew, D. A., and V. M. Bendelow. 1963. The effects of swathing at different stages of maturity on the malting quality of barley. Can. J. Plant Sci. 43:534-41.

7. Harlan, R. V. 1923. Water content of barley kernels during growth and maturation. J. of Agric. Res. 23:333-60.

8. Harris, R. H. and O. J. Banasik. 1951. Effects of environment, variety, and season on barley quality. Cereal Chem. 29:148-55.

9. Koenig, R. F., D. W. Robertson, and A. D. Dickson. 1965. Effect of time of swathing on malting barley quality. Crop Sci. 5:159-61.

10. McLean, D. M. 1933. The effects of harvesting at different stages of maturity upon the yield and chemical composition of barley. Sci. Agric. 13:698-713.

APPENDIX

TABLE IV

CULTIVAR MEANS FOR CHARACTER
PERCENT THIN KERNELS

Entry No.	Rank	Variety or Pedigree	Means
8	1	Kirmese 5/Cordova//Kerr	3.35
14	2	Mo. B2126	3.87
9	3	Kirmse 5/Cordova//Kerr	4.43
1	4	Mich-62-449-22	6.56
10	5	MsTrophy/Harrison	7.19
6	6	MsTrophy/Will	8.66
15	7	63AB2961/Ione	8.93
2	8	NY6005-18	11.09
17	9	63AB2961/Ione	11.55
20	10	63AB2987/Ione	12.06
19	11	63AB2987/Ione	12.83
11	12	MsTrophy/Harrison	13.10
12	13	MsTrophy/Will	13.67
16	14	63AB2961/Ione	14.43
3	15	MsTrophy/Will	14.53
18	16	63AB2961/Ione	15.41
13	17	MsTrophy/Will	16.63
4	18	67x1D/Dickson	16.69
7	19	Kerr	17.35
5	20	67x1D/Dickson	28.90
21	21	63AB2987/Ione	30.00
22	22	Wade/Luther	42.98

LSD .05 = 7.56

LSD .01 = 10.11

TABLE V

CULTIVAR MEANS FOR CHARACTER
PERCENT KERNEL PROTEIN

Entry No.	Rank	Variety or Pedigree	Means
4	1	67x1D/Dickson	12.57
1	2	Mich-62-449-22	12.92
17	3	63AB2961/Ione	13.04
3	4	MsTrophy/Will	13.07
10	5	MsTrophy/Will	13.09
16	6	63AB2961/Ione	13.09
21	7	63AB2987/Ione	13.15
6	8	MsTrophy/Will	13.38
15	9	63AB2961/Ione	13.58
13	10	MsTrophy/Will	13.65
14	11	Mo. B2126	13.67
11	12	MsTrophy/Harrison	13.85
12	13	MsTrophy/Will	13.97
20	14	63AB2987/Ione	14.03
18	15	63AB2961/Ione	14.05
2	16	NY6005-18	14.08
7	17	Kerr	14.25
8	18	Kirmse 5/Cordova//Kerr	14.37
9	19	Kirmse 5/Cordova//Kerr	14.40
5	20	67x1D/Dickson	14.68
20	21	63AB2987/Ione	14.71
22	22	Wade/Luther	14.72

LSD .05 = .79

LSD .01 = 1.06

TABLE VI

CULTIVAR MEANS FOR CHARACTER
GRAIN YIELD

Entry No.	Rank	Variety or Pedigree	Means (kg/ha)
3	1	MsTrophy/Will	5943.88
2	2	NY6005-18	5735.68
18	3	63AB2961/Ione	5500.61
1	4	Mich-62-449-22	5498.35
9	5	Kirmse 5/Cordova//Kerr	5247.63
16	6	63AB2961/Ione	5097.63
17	7	63AB2961/Ione	5050.62
15	8	63AB2961/Ione	4945.40
7	9	Kerr	4833.46
21	10	63AB2987/Ione	4748.39
6	11	MsTrophy/Will	4535.71
8	12	Kirmse 5/Cordova//Kerr	4517.80
22	13	Wade/Luther	4204.37
14	14	Mo. B2126	4103.63
19	15	63AB2987/Ione	4099.15
12	16	MsTrophy/Will	4036.47
11	17	MsTrophy/Harrison	3738.71
5	18	67x1D/Dickson	3738.71
10	19	MsTrophy/Harrison	3684.98
13	20	MsTrophy/Will	3483.50
4	21	67x1D/Dickson	3275.29
20	22	63AB2987/Ione	3078.28

LSD .05 = 1273.95

LSD .01 = 1703.21

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VITA

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