UNIVERSITY OF IDAHO

College of Agriculture

NITROGEN FERTILIZER IMPROVES QUALITY OF HARD RED WINTER WHEAT IN EASTERN IDAHO

R. J. Schaeffer and K. H. W. Klages

IDAHO Agricultural Experiment Station

Bulletin No. 461
May 1966

Acknowledgments

Sincere gratitude is expressed to the following landowners and cooperators for the plot ground used in this study. Their assistance and counsel in selecting and establishing the plots was greatly appreciated, as was their spirit of cooperation which helped make the study pleasant and enjoyable.

Mrs. Lorene Rhodes, Idaho Falls, Idaho
Mr. Jim Hayes, Idaho Falls, Idaho (Antelope Flat)
Mr. Bill Simon, Fairfield, Idaho
Mr. Dick Smith, Rexburg, Idaho
Mr. Frank Webster, Rexburg, Idaho
Mr. Bill Webster, Rexburg, Idaho
Mr. Jack Richards, American Falls, Idaho (Roy)
Mr. Ray Johnson, Burley, Idaho (Heglar)
Mr. John Hansen, Malad City, Idaho (Pocatello Valley)
Mr. Evan Koller, Weston, Idaho
Mr. LaVell Koller, Weston, Idaho

Sincere appreciation is also extended to the Idaho Wheat Growers' Association, and the Idaho Wheat Commission, who provided the total financial support of this study.

Special thanks is given to Mr. Vard Meadows, American Falls; Dr. Wade Dewey, Utah State University, Logan, Utah; and Mr. Hugh McKay, Superintendent, Tetonia Branch Experiment Station, St. Anthony; for providing the seed wheat used in this study.

Contents

Summary and Recommendations 3
Introduction 5
Location, Methods and Procedures 6
Growing Conditions and Wheat Survival 7
Results 8
    Fertility Results 10
    Annual Results 10
    Rainfall and Soil Moisture 11
    Soil Fertility 12
Discussion of Results by Area 13
Rate and Date of Seeding 18

Summary and Recommendations

Five varieties of hard red winter wheat were grown at 8 locations. There were no significant yield differences in the varieties tested, Table 1, page 8.

Tendoy was placed on the top of the variety list on account of its high resistance to stripe rust. The quality of this variety was good. This is evident from the data on test weight, protein percentages, sedimentation, farinograph peaks, flour yields and water absorption.

The performance of Itana was excellent with one exception, the water absorption was low.

Turkey is an old variety. Its main objection is that it is susceptible to both common and dwarf smut.

Cache is a good yielding variety but lowest in quality factors. The growing of this variety should be discontinued.

Columbia was the lowest yielding variety in the test. It should be replaced by either Tendoy or Itana.

All quality factors and average effects showed improvements with increasing applications of N, Table 2, page 8.

Fertility, Yearly Effects, 1961-64

Table 3, page 9, shows the quality factors of varieties and average response on an annual basis. The yields of varieties by years did not indicate increases. Cache was low again in sedimentation.

The 60-pound rate of nitrogen applications produced the highest overall yields and quality. Each increase in N applications accounted for an increase of one percent protein response, Table 4, page 10.

Rainfall and Soil Moisture

Precipitation and the availability of soil moisture is very important to the production of winter wheat. Studies showed that the plots grown north of the Snake River received more moisture than those located to the south of the river, Table 5, page 11.

High moisture years produce high yields, unfortunately often at the expense of quality.

Results by Areas

Nitrogen appears to be the only element capable of increasing yields and quality of wheat in the areas under study. It was the only element capable of giving response or economical returns.

Of the areas located south of the Snake River, the Heglar area showed the greatest and most consistent response to nitrogen applications, Tables 6 and 7, pages 12 and 13. Sixty pound applications of N yielded only slightly more than 30 pounds. However, the quality of the crops was slightly greater than for the higher rate, 60 pounds per acre.

There was no response to N applications during the first 2 years of the test at Roy. The third year produced high yields as a result of favorable precipitation and applications to N. The protein increases were rather modest. For the sake of quality production, 30-60 pounds of N could be used, Table 8, page 14.

Table 9, page 15, indicates that N applications actually reduced wheat yields in the Weston area. Quality of grain remained untouched by all rates of application. This represents a case where the plots in question are located on rich soil not requiring additional N.

Producers in the Rexburg area are concerned with quality N applications. Protein was low even at the higher levels of applications of N. Sedimentation was poor at all levels of N applications, Table 10, page 15.

The soils used at Fairfield are fertile. Not more than 30 pounds of N per acre seems sufficient for some time to come. Table 12, page 17, shows good yields not influenced by N availability. Fairfield wheat is of good quality. This is well indicated by high yields, test weights, protein and sedimentation.

Rates and Dates of Seeding

The time of seeding in the areas under study should generally be delayed until after September 1, especially in those areas where heavy fall foliage might increase the prevalence of disease. Early seeding has produced higher yields but protein quantity and quality has been poor. Seeding rates of 40 pounds per acre have been adequate. The 60-pound rate produces higher yields but poorer quality wheat. If the seeding date must be delayed to around October 1, the 60-pound rate is recommended, especially at high elevations.

See Table 13, page 19, for tabulated data.

NITROGEN FERTILIZER IMPROVES QUALITY OF HARD RED WINTER WHEAT IN EASTERN IDAHO

R. J. Schaeffer*

and

K. H. W. Klages†

INTRODUCTION

This investigation was devoted to the various problems encountered in the production of high yielding, quality, hard red winter wheat in the drylands of Southeastern Idaho. The task involved several problems including the evaluation of varieties adapted to the area, the effect of nitrogen and other fertilizers on yield and quality of the wheat, the response of winter wheat to dates and rates of seeding.

---

*Agronomist, Northrup King and Company, Twin Falls, and former Assistant Agronomist Jr., Aberdeen Branch Experiment Station, Aberdeen.

†Former Head, Department of Agronomy, University of Idaho.

Five varieties of hard red winter wheat were included in the tests conducted. Two varieties, Tendoy and Itana, produced high yields and good quality grain. Tendoy had the advantage of almost complete resistance to stripe rust while Itana was susceptible to this disease. Tendoy had the disadvantage of being quite susceptible to shattering.

Nitrogen applications of 30 to 60 pounds per acre per crop year generally resulted in only moderate increases in yields. Unfortunately the yields were, in most instances, not increased sufficiently to be economic except at Fairfield, Roy, Rexburg and certain other areas. Fields to which moderate amounts of nitrogen were added gave highly variable yields. Work by the Tetonia Branch Station, including more years, indicated economic returns could be expected on the Rexburg Bench.

Much of Idaho's wheat is soft and low in protein. Flour produced from this kind of wheat is of low quality. High quality bread flour demands protein and strength. Hard wheats produced in the Great Plains have these desirable characteristics and are blended with our wheat. This necessitates the importation of the strong wheats from the Plains area. It solves the question of need but increases costs. Data reported here show that greater use of approved varieties and nitrogen will permit high quality wheat production in Southeastern Idaho. This could maintain and increase market outlets.

Wheat buyers and millers recognize a pronounced difference in the quality of bread made from certain varieties of wheat although the percent protein may be the same. Gluten quality contributes this difference and may be measured in the laboratory by sedimentation and farinograph peak tests. In both tests the higher value indicates better gluten quality.

LOCATIONS, METHODS AND PROCEDURES

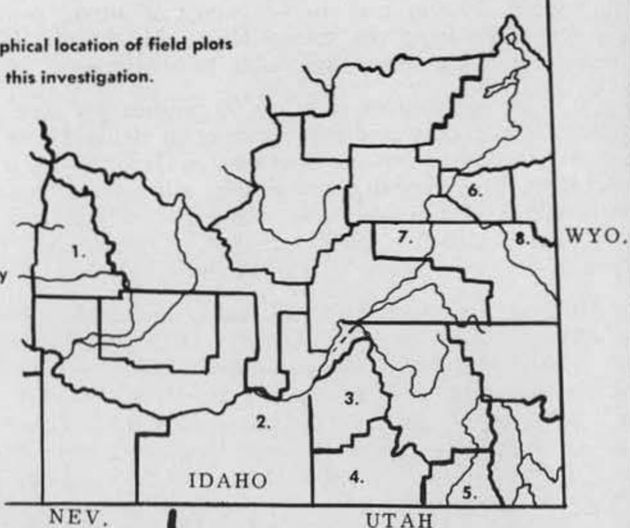
Studies were conducted at 8 locations during the 4-year period from 1960 to 1964, with plots at Fairfield, Roy, Weston, Idaho Falls, Heglar, Rexburg, Pocatello Valley and Antelope Flat. Some plots were lost each year due to adverse weather and/or disease and weed conditions. An average of 5 locations was harvested each year. Figure 1 shows the geographic locations of the experimental plots used in these investigations.

The plot land was prepared by the farmers following normal fallow and seedbed operations. Seeding was done with a 14-inch spaced, 8-row, deep furrow drill equipped with press wheels. The plots were harvested with a 7-foot cut, self-propelled combine. Quality and yield were determined for 6 of the 8 rows planted. The quality analysis was made by the wheat quality laboratory at the Aberdeen Branch Station.

The fertilizer variety trials consisted of duplicated fertilizer blocks of 4 rates of ammonium nitrate (33.5 percent N) applied before drilling. Four replications of 5 varieties were planted throughout the study. The varieties used were Itana, Tendoy, Columbia, Cache and Turkey. All the varieties were seeded at a rate of 40 pounds per acre. Seeding dates ranged from August 28 to September 13. A total of 80 sub-plots, each 1/100 acre in size, constituted the trial at each location.

Figure 1. Geographical location of field plots used in this investigation.

1. Fairfield
2. Heglar
3. Roy
4. Pocatello Valley
5. Weston
6. Rexburg
7. Idaho Falls
8. Antelope Flats



Growing Conditions and Wheat Survival

The climatic conditions during the 4 growing seasons were quite variable. The 1960-61 season was considerably drier and hotter than normal resulting in low yields of high protein wheat at 4 locations.

In the 1961-62 season plots were planted at 8 locations. The plot at Idaho Falls was killed by an open snow-free winter with severe low temperatures. The plot at Antelope Flat was killed by snow mold. The plot at Rexburg was invaded early in the fall by downy bromegrass, *Bromus tectorum*. Cultivation with a rotary hoe and the use of chemicals gave some control, but the resulting plot stand was not uniform enough for gathering valid data, consequently the plot was not harvested. Increased rainfall over the 1960-61 season produced higher yields with satisfactory protein levels.

Inadequate soil moisture for seed germination at planting time prevented the emergence of the plot at Pocatello Valley in the 1962-63 season. The plot at Roy was hailed out completely in June 1963. The remaining 6 plots produced uniformly heavy stands, due mainly to the above-normal spring rains. However, an abrupt cessation of rainfall about heading time resulted in soil moisture depletion as the plants approached maturity. In this instance, the heavier fertilizer rates produced rank vegetation and yields decreased.

The 1963-64 season plantings were made at 8 locations. At Weston the heavy fall foliage was subjected to severe seedling stripe rust, some wheat streak mosaic, severe snow mold, and mouse damage under a heavy snow blanket, resulting in the plot being a total loss. The plot at Antelope Flat was lost to snow mold, even though the plot had been sprayed in the fall with 5 pints of Ceresan-M per acre. At other locations treated for snow mold the treatment was effective and good stands resulted. At Pocatello Valley dwarf smut was so severe in all varieties and all nitrogen treatments that valid data could not be obtained. Frequent spring rains of moderate intensity provided good soil moisture conditions, and the heaviest yields of the 4-year study were obtained at the remaining 5 locations.

RESULTS

Tables 1 and 2 show the average 4-year effect of variety and nitrogren fertilizer rates on the agronomic and quality factors of hard red winter wheat grown at the 8 locations. Varietal yield differences averaged 2.7 bushels per acre between Itana, the highest average yielding variety, and Columbia, the lowest average yielding variety.

In obtaining the variety response average, all the fertilizer treatment rate effects were averaged.

There is no difference among varieties in test weight or percent protein where optimum fertility levels were found.

Cache has consistently produced wheat of low sedimentation value regardless of yield or percent protein. The character of poor gluten quality in Cache is further emphasized in the farinograph test where the values fell within the 5 to 6 minute range limit set as standard by the milling industry in only 2 locations or years, with an average peak time of 4.4 minutes in the 4-year study.

Flour yield of each variety tested was about the same, with Itana yielding slightly more flour per 100 pounds of wheat than Cache or Columbia. However, Itana has consistently had a lower water absorption ability than the other varieties. This continues to be one of the more serious shortcomings of Itana as far as bakers are concerned.

Table 1. Yield and quality of five varieties of hard red winter wheat grown at eight locations over a four-year period

Varieties	bu. acre	Test wt.	Plant height	Protein %	Sedimentation	Farinograph peak	Flour yield	Water absorption
Itana	31.6	60.8	34.5	12.7	61.5	10.8	64.7	58.2
Tendoy	31.0	60.5	33.6	13.2	62.2	9.3	64.4	61.1
Columbia	28.9	60.3	31.2	13.8	63.4	10.3	63.7	60.8
Turkey	29.1	59.6	31.7	13.2	62.4	6.9	64.1	62.3
Cache	31.0	60.0	32.8	13.1	52.8	4.4	63.0	64.4
Average	30.1	60.2	32.8	13.2	60.5	8.3	64.0	61.4

Table 2. Effects of ammonium nitrate on agronomic and quality factors over a four-year period at five locations harvested per year. Average all five varieties

N rate	bu. acre	Test wt.	Plant height	Protein %	Sedimentation	Farinograph peak	Flour yield	Water absorption
90	29.9	59.5	33.4	14.4	65.4	9.9	64.0	62.4
60	31.1	60.0	33.0	13.8	62.5	9.2	64.0	61.9
30	30.7	60.6	32.6	12.7	58.8	7.6	63.9	60.9
0	29.6	61.0	31.6	11.8	54.5	5.3	64.0	60.0
Average 45	30.3	60.3	32.7	13.2	60.3	8.0	63.9	61.3

Fertility Results

Table 2 shows the average response of the 5 varieties to 4 nitrogen levels. The 60-pound rate of N produced the highest overall yield, averaging 1.5 bushels per acre more than the 0-pound rate. Test weight was reduced to 59.5 pounds per bushel by the 90-pound N rate when averaging varieties, locations, and years. This reduction is not too serious, but the reduction was quite severe at some locations in some years at the high N rates. Plant height shows a response to N fertilizer in the total area covered by this investigation. The plant height response is due primarily to the relatively ample moisture supplies received during the spring and early summer period. The limiting factor in producing high grain yields is the shortage of available moisture adequately to finish the crop to maturity. This was the case especially in certain locations in 1963.

The data in Table 2 show a very definite protein response to nitrogen with each increase in N rate increasing the protein level about 1 percent. Some areas had good protein levels without fertilizer use but other areas produced protein levels as low as 7.8 percent. Sedimentation and farinograph peak are also favorably affected by the increased N rates. The farinograph peak time of 5.3 minutes for the 0-pound rate is barely acceptable. Some varieties in certain areas produced peak time averages as low as 2.1 minutes. The farinograph peak time is closely associated with the sedimen-

Table 3. Agronomic and quality averages by varieties, means and yearly effects

Year	Varieties	Yields per acre	Protein %	Sedimentation
1961	Itana	25.5	14.1	71.8
	Tendoy	23.0	14.7	69.3
	Columbia	21.6	15.1	71.9
	Turkey	21.8	14.0	71.4
	Cache	22.4	14.6	57.2
	Average	22.9	14.5	68.3
1962	Itana	31.5	13.6	69.8
	Tendoy	30.9	13.6	69.6
	Columbia	28.8	14.9	71.5
	Turkey	29.4	13.4	69.7
	Cache	32.5	13.3	59.1
	Average	30.6	13.8	67.9
1963	Itana	33.8	11.8	56.4
	Tendoy	35.0	12.3	57.0
	Columbia	31.8	12.8	57.8
	Turkey	31.3	13.2	55.8
	Cache	32.5	12.4	43.1
	Average	32.9	12.5	54.0
1964	Itana	35.7	11.3	41.8
	Tendoy	35.1	12.2	53.0
	Columbia	33.4	12.4	52.4
	Turkey	33.8	12.3	52.6
	Cache	36.5	12.2	41.9
	Average	34.9	12.1	48.3

tation value. Sedimentation values under 50 have nearly always yielded a farinograph peak time considerably under 5 minutes.

Annual Results

Table 3 shows the varietal response by years, averaging all the locations harvested during the particular year. This table shows that when considering the arithmetical mean of the varieties by averaging the fertilizer rates, yields rose each year from 1961 to 1964, with good test weight in the two latter, higher producing years. Protein percent and sedimentation values declined as the yield and test weight increased. Protein and sedimentation levels of the 1964 averages showed this to be a rather mediocre year for quality, especially since these values represent an average of all fertilizer responses.

Table 4 shows the results of the different fertilizer rates by years. In 1961 yield and test weight were low, while protein and sedimentation values were high. In 1962 the response was similar although the yield had increased considerably, and the sedimentation values showed a significant response to the higher fertilizer rates. The higher fertilizer levels in the 1963 crop showed the effects of soil moisture depletion as the crop approached maturity, namely reduced yields and reduced test weights. It is noteworthy that the 30-pound N rate produced as much yield with considerably more quality than did the check rate.

In 1964, when adequate soil moisture prevailed throughout the growing season, the 60-pound N rate produced 3.6 bu/A more than the 30-

Table 4. Agronomic and quality averages by N rates and an average of varities by years

Year	N rate	Yields per acre	Protein %	Sedimentation
1961	90	22.6	15.1	69.4
	60	23.1	15.4	70.2
	30	23.2	14.1	69.6
	0	22.6	13.2	69.7
Average	45	22.9	14.5	69.7
1962	90	29.3	15.0	70.8
	60	31.2	14.1	69.6
	30	31.3	13.3	67.2
	0	30.7	12.6	64.1
Average	45	30.6	13.8	67.9
1963	90	30.4	14.0	64.3
	60	32.7	13.0	57.5
	30	34.3	11.8	51.2
	0	34.2	11.2	43.1
Average	45	32.9	12.5	54.0
1964	90	37.2	13.5	57.1
	60	37.6	12.6	52.9
	30	34.0	11.5	47.2
	0	30.8	10.7	41.2
Average	45	34.9	12.1	49.6

pound N rate, and 6.8 bu/A more than the check rate. This is a highly significant yield increase. The high yield was accompanied by high test weight, a normal association, but in addition the protein content remained high with acceptable gluten quality indicated by the farinograph peak. The check and 30-pound N rates were deficient both in protein quantity and quality.

Rainfall and Soil Moisture

The availability of moisture is one of the most important factors in winter wheat production in dryland areas. This factor determines not only yields but also influences the quality of the crop harvested.

The highest precipitation months are essentially April, May, and June. The December and January high curve plateau of 1.26 inches reflects mainly the higher precipitation at Fairfield which receives an average of 2.22 inches in January. The high monthly average of 1.42 inches occurs in May.

Of more importance, and more directly applicable to the yield and quality of wheat grown in eastern Idaho, is the amount of precipitation which enters the soil and is stored for the production of the crop. The highest soil moisture level was obtained at all locations in the early spring, reflecting the increased rainfall of the April and the early May period as well as the accumulation of winter precipitation. The amount of soil moisture available for crop growth was calculated as that determined in the early spring minus the permanent wilting percent of the particular soil.

Soil moisture was determined and converted to inches of available moisture per foot by the soil density factor. The total inches of soil moisture available in the 5-foot profile ranged from 4.36 to 8.63 inches south of the Snake River and from 8.17 to 11.33 inches north of the river, as shown in Table 5. It should be noted that the moisture depletion for Roy, Heglar, Pocatello Valley, and Idaho Falls, showing an average of 87 percent, came from the upper 3 feet. At Rexburg, where there is a solid rock shelf between the 4- and 5-foot depth of most of the area, the moisture

Table 5. Four-year average of soil moisture data from eight stations to a depth of five feet

Plot location	Available soil moisture at start of growing season	Moisture depletion during growing season	Available moisture at end of growing season
North of Snake River	**Inches**	**Inches**	**Inches**
Idaho Falls	8.17	6.83	1.34
Rexburg	9.48	8.88	0.60
Antelope Flat	11.33	10.33	1.00
Fairfield	8.33	7.16	1.16
Average	9.33	8.30	1.03
South of Snake River			
Roy	7.49	5.65	1.84
Heglar	7.12	5.91	1.21
Pocatello Valley	4.36	4.30	0.06
Weston	8.63	8.18	0.45
Average	6.90	6.01	0.89

used was 55 percent and 45 percent for the upper and lower 2-foot levels respectively. At all locations moisture depletion was less than the total moisture availability in the 5-foot profile, with Pocatello Valley nearing the zero moisture reserve.

Soil Fertility

Another factor pertinent to the production of hard red winter wheat in eastern Idaho is the fertility level of the soil. At the beginning of the study, soil samples were taken at 5 locations to a depth of 6 to 8 inches (plow layer), after the fallow season and before planting, and analyzed for pH, organic matter, phosphorus (P_2O_5), potash (K_2O), sulfate sulfur (SO_2), and total salts.

As the study progressed, repeat applications of nitrogen fertilizer were made to the same plots as previously in an attempt to determine the N build-up, or residual. Soil samples were taken before much plant growth had occurred in the spring of 1964 at 1-foot intervals to a depth of 5 feet, and analyzed for available N in both the NO_3 and NH_3 form. Samples were taken from the check and the 60-pound 1960 analysis. It is interesting to note that values for pH, organic matter, and potash, did not change much in 4 years, and variations were probably well within the normal sampling error range. Organic matter levels tended to decrease during the 4-year study when compared to the original tests. The levels of potash also show a decrease, but remain sufficiently high for crop production at all locations.

Table 6. Yield and quality data by varieties at Heglar during three crop years of N applications to five varieties of hard red winter wheat

Year	Varieties	Yield bu/acre	Test wt.	Plant height	Protein %	Sedimentation
1961-62	Itana	28.3	60.2	32.6	13.7	72.5
	Tendoy	27.4	60.0	31.2	13.5	72.0
	Columbia	27.0	59.9	29.9	15.0	72.3
	Turkey	28.9	59.1	31.0	13.1	71.5
	Cache	30.8	59.2	32.6	13.4	62.5
1962-63	Itana	41.6	62.2	37.8	9.6	51.5
	Tendoy	36.9	61.0	37.3	10.6	44.0
	Columbia	42.6	63.6	33.6	11.1	47.5
	Turkey	35.3	61.4	35.1	11.0	43.0
	Cache	29.6	61.8	36.7	10.6	35.2
1963-64	Itana	33.1	60.0	37.8	11.6	45.0
	Tendoy	32.9	59.7	37.6	12.5	47.9
	Columbia	27.4	59.3	33.6	12.2	47.1
	Turkey	30.9	58.5	36.8	12.3	53.8
	Cache	33.6	58.9	37.5	12.6	38.3
Average	Itana	33.7	60.8	36.1	11.6	56.3
	Tendoy	32.4	60.2	35.4	12.2	54.6
	Columbia	32.3	60.9	32.4	12.8	55.6
	Turkey	31.7	59.7	34.3	12.1	56.1
	Cache	34.7	60.0	35.6	12.2	45.3

Table 7. Yield and quality data for an average of five varieties of hard red winter wheat at Heglar for three crop years with four rates of nitrogen

Year	Nitrogen rates	Yield bu/acre	Test wt.	Plant height in inches	Protein %	Sedimentation
1961-62	90	28.2	58.6	31.7	15.5	72.6
	60	28.1	59.0	31.6	14.3	72.2
	30	29.5	60.1	31.1	13.1	68.4
	0	28.1	61.0	31.6	12.2	67.4
1962-63	90	41.6	60.7	37.2	12.4	56.8
	60	42.3	62.1	36.6	10.8	46.4
	30	39.2	62.6	36.8	9.9	40.8
	0	33.6	62.6	33.8	9.3	33.0
1963-64	90	31.4	56.8	37.8	14.8	60.4
	60	32.3	58.9	38.6	13.1	53.0
	30	33.1	60.7	36.7	11.1	41.4
	0	29.5	60.7	33.6	9.8	30.8
Averages	90	33.7	58.7	35.6	14.2	63.3
	60	34.2	60.0	35.6	12.7	57.2
	30	33.9	61.1	34.9	11.4	50.2
	0	30.4	61.4	33.0	10.5	43.7

DISCUSSION OF RESULTS BY AREA

The main consideration in evaluating the results of this study is that pertaining to wheat quality in response to nitrogen fertilizer. In presenting the results by location, the variety response data (e.g. Table 6, for Heglar) are given as a matter of information to indicate the average variety differences by years in regard to yield, test weight, plant height, percent protein, and sedimentation. These differences are in response to an average of the fertilizer rates. The main emphasis of the study, however (e.g. Table 7, for Heglar) is placed on the total response to the specific N rates wherein the variety responses are averaged within the N treatment.

Of the areas located south of the Snake River, Heglar had the greatest and most consistent response to N fertilization (Tables 6 and 7). The 3-year average increase of 3.5 bushels over that of the check was sufficiently high to pay for a 30-pound application. Sixty pounds of N per acre yielded only slightly more than was obtained with the 30-pound rate but a superior quality of wheat was produced with the higher rate of application.

Table 6 shows the seasonal and annual yield obtained at Heglar by the response of 5 varieties of winter wheat. Table 7 shows the response to 4 rates of N applications at Heglar for 3 crop years.

In order to produce quality wheat at Heglar the 60-pound N rate was required in 1963-64. In the 1962-63 crop year adequate protein quantity and quality were not obtained with less than 90 pounds N. In both years significant yield increases were obtained by the use of N. In 1961-62, there was no statistical difference in yield due to N fertilizer, although a significant reduction in test weight resulted from inadquate soil moisture to mature the crop at the higher N rates. The test weight reduction was not considered severe and the resulting protein and sedimentation qualities were excellent. The quality factors of the check plot were also satisfactory that year.

The high yields produced at Heglar in 1962-63 illustrate the increased demands put on soil N in the production of good protein quantity and quality under more optimum growth conditions. Although the measured rainfall at the plot for that season totalled only 8.2 inches, the timeliness of the rains produced high yields without exhausting the available soil moisture supply. While the 60-pound N rate produced the highest yield, there was inadequate N available to produce both high yield and high quality.

Table 8. Yield and quality data by N rate at Roy for three crop years, an average of all variety response

Year	Nitrogen rates	Yield bu/acre	Test wt.	Plant height in inches	Protein %	Sedimentation
1960-61	90	31.7	60.5		13.2	
	60	30.5	59.2		15.0	
	30	32.3	61.7		11.3	
	0	29.4	62.4		9.9	
1961-62	90	25.2	58.1	24.1	13.6	68.0
	60	26.8	58.9	24.8	12.3	64.4
	30	26.2	59.8	25.2	11.4	60.0
	0	26.2	60.9	25.2	10.1	48.0
1963-64	90	38.7	60.3	41.5	13.1	48.6
	60	37.7	61.7	40.1	11.4	39.7
	30	32.6	61.9	36.1	10.5	35.7
	0	25.5	61.9	31.8	9.7	29.8
Averages	90	31.9	59.6	32.8	13.3	58.3
	60	31.7	59.9	32.4	12.9	52.0
	30	30.4	61.1	30.6	11.1	47.8
	0	27.0	61.7	28.5	9.9	38.9

During the first 2 years of the study at Roy, Table 8, there was no yield response to N rates. Acceptable quality protein was not produced at rates of less than 60 pounds N per acre. In 1963-64 highly significant yield and protein increases resulted from a 90-pound N rate. The 60-pound N rate produced a high yield with less than desirable protein quality. The response of the 3 crop years show a substantial yield increase at the 30- and 60-pound N rate, with 60 pounds of N being required to produce good protein quality as indicated by the percent protein and the sedimentation values.

At the plot located four miles west of Weston, Table 9, the N fertilizer has generally decreased yields, suggesting that the soil fertility levels are adequate. Relatively high yields in 1961-62 showed no response to N, and, although there is a statistical difference in percent protein, the protein levels and sedimentation values were excellent at all N rates. In 1962-63, the increased yield potential of the 60- and 90-pound N rates evidenced by heavier vegetation was actually reversed by the soil moisture shortage at crop maturity, resulting in decreased yields of high protein grain.

At Pocatello Valley, (8 miles southwest of Malad City) only the initial planting in 1961-62 survived to harvest. The 2 subsequent plantings were lost due to inadequate soil moisture at planting in the fall of 1962, and the severe dwarf smut invasion of that area in the summer of 1964.

There was no difference in yield due to fertilizer in the one crop harvested. Test weight decreased significantly as the N rate increased. Protein percent increased significantly with each increase in N rate, although the protein content was satisfactory at all N rates. Sedimentation values also increased from the additional N.

Table 9. Yield and quality data by N response at Weston for three crop years, an average of all variety response

Year	Nitrogen rates	Yield bu/acre	Test wt.	Plant height in inches	Protein %	Sedimentation
1960-61	90	15.9	61.0		14.8	68.4
	60	19.4	61.3		14.7	68.9
	30	16.1	61.3		14.5	68.1
	0	17.8	61.6		14.2	67.6
1961-62	90	35.8	61.8	33.4	14.7	72.8
	60	34.8	61.9	33.2	14.6	71.6
	30	36.2	62.2	33.8	14.4	70.6
	0	36.0	62.0	36.6	14.3	70.2
1962-63	90	24.9	61.2	33.7	14.1	65.8
	60	28.2	61.6	35.6	13.9	65.0
	30	30.7	61.8	35.8	13.0	61.0
	0	30.5	62.4	34.2	12.6	55.6
Averages	90	25.5	61.3	33.5	14.5	69.0
	60	27.0	61.6	34.4	14.4	68.5
	30	27.7	61.8	34.8	14.0	66.6
	0	28.1	62.0	33.4	13.7	64.5

In the areas located north of the Snake River, protein quality has been a matter of concern mainly at Rexburg, as the other areas produced more acceptable protein. On plots located in the vicinty of the Walker elevator 8 miles southeast of Rexburg, protein quality and quantity were below the acceptable standard for all N rates less than 90 pounds per acre, as shown in Table 10. In the 1962-63 crop year of about normal yields, protein and sedimentation values were low up to and including the 60-

Table 10. Yield and quality data by N rate at Rexburg during two crop years, an average of all varieties

Year	Nitrogen rates	Yield bu/acre	Test wt.	Plant height in inches	Protein %	Sedimentation
1962-63	90	26.8	55.2	38.0	12.9	61.2
	60	31.0	57.4	37.9	11.4	45.0
	30	33.1	59.2	37.1	9.3	30.6
	0	30.7	59.2	33.4	7.6	23.6
1963-64	90	41.8	61.2		11.9	48.4
	60	40.0	61.1		11.5	45.8
	30	32.8	60.6		9.3	32.4
	0	29.1	60.5		9.0	29.2
Averages	90	34.3	58.2		12.4	54.8
	60	35.5	59.2		11.4	45.4
	30	32.9	59.9		9.3	31.5
	0	29.9	59.8		8.3	30.4

pound N rate. In addition, the test weight values were considered poor, as the 60- and 90-pound N rate produced test weights below number 2 grade. Although the yield at the 30-pound N rate, when compared to the check, increased by 2.4 bushels per acre for that year, the wheat produced was of very poor quality. The abrupt cessation of rainfall during the 1962-63 season at about heading time had a depressive effect on the yield potential that was indicated by the increased plant height of the high N rates. The measured rainfall of 12.62 inches could, under more normal distribution, produce higher yields than were obtained.

In 1963-64 the total rainfall measured 12.05 inches and was more evenly distributed throughout the growing season, for a total of 24.67 inches from one harvest to another. The total moisture depletion equalled 3.16 inches more per 5-foot depth than in the previous crop, and the yield response to N fertilizer was highly significant. The 90-pound N rate produced 12.7 bushels more per acre than the check plot. The check plot yield compared very closely with that of the year before. The plots planted in the first 2 years of the study did not survive to be harvested. The 1960-61 crop season was much drier and may have produced results quite different than reported here. However, based on the results of the 2 years harvested, the benefits of N fertilizer are quite evident. The measured precipitation in the 2 years exceeded by only .86 inches the long-time average of the nearest official station. It appears that additional N is needed to obtain maximum yields, and that N in excess of yield increase response is needed to produce high milling quality wheat.

One-year data were obtained at Antelope Flat located 15 miles east of Ririe. Much of the 16.8 inch measured rainfall for the 1962-63 crop was received in the early spring. Vegetative responses were good with dense stands being produced with the higher N rates. Turkey and Cache lodged under the heavy growth, and yield was reduced mainly by the wheat being so flat on the ground that it could not be picked up by the combine. The high protein levels, however, suggest some other contributing growth arresting factors — possibly foot and root rot. Itana and Columbia were severely attacked by stripe rust with severe reductions in yield. Itana was affected more than Columbia. The resistance of Tendoy to stripe rust was amply demonstrated by the high yields of that variety. Considerable seedling infection had occurred on Tendoy, but as the plants grew they developed a high resistance to the disease. The plant height of Itana exceeded that of Tendoy or Columbia, but all 3 varieties produced heavy growth with no lodging.

The heavy vegetation growth coupled with high grain yield made heavy demands on soil moisture and soil moisture samples taken after harvest show the available soil moisture exhausted at the 3- and 4-foot depth. This resulted in the check giving the highest yield with the yield dropping as the nitrogen level increased. Protein was satisfactory at 30 pounds N or higher. See Table 10, page 15.

At the plot located 8 miles southeast of Idaho Falls on the Bone road, the low soil moisture supply during the 1960-61 season precluded any yield response to the higher N rates, although the protein response was highly significant at all N rates when compared to the check. The fairly heavy spring rainfall which occurred in the 1962-63 crop season resulted in heavy vegetative responses to the higher N rates, as shown by the increased plant

Table 11. Yield and quality data by N response at Idaho Falls for three crop years, an average of all variety response

Year	Nitrogen rates	Yield bu/acre	Test wt.	Plant height in inches	Protein %	Sedimentation
1960-61	90	22.9	58.3		16.4	
	60	22.0	58.5		16.1	
	30	22.4	59.3		14.9	
	0	22.6	60.1		13.1	
1962-63	90	19.9	53.6	34.8	15.6	68.0
	60	22.2	53.3	35.1	14.5	65.0
	30	27.8	55.6	34.5	13.0	56.4
	0	31.9	57.8	32.8	11.4	45.6
1963-64	90	41.8	61.9	37.7	13.5	63.9
	60	42.3	62.3	35.4	13.0	62.8
	30	38.8	62.0	35.2	12.8	63.7
	0	39.5	62.9	34.8	11.8	57.8
Averages	90	28.2	57.9	36.2	15.2	65.9
	60	28.8	58.0	35.2	14.5	62.9
	30	29.7	59.0	34.8	13.2	60.0
	0	31.3	60.3	33.8	12.1	51.7

height. However, the severely dry period from before heading to harvest resulted in drastic reduction in yield, especially at the 60- and 90-pound N rates. The low protein and sedimentation values produced by the check

Table 12. Yield and quality data by N rate at Fairfield during four crop years, an average of all varieties

Year	Nitrogen rates	Yield bu/acre	Test wt.	Plant height in inches	Protein %	Sedimentation
1960-61	90	20.1	59.4		16.4	
	60	20.7	59.2		16.1	
	30	21.9	59.2		14.9	
	0	20.6	59.2		13.1	
1961-62	90	30.9	57.1	28.0	15.4	69.6
	60	36.7	58.2	28.2	14.6	69.6
	30	35.2	58.4	28.5	14.2	69.4
	0	33.3	57.1	29.1	14.2	69.6
1962-63	90	34.1	61.6	36.9	15.1	70.8
	60	31.3	61.9	35.5	14.5	69.8
	30	31.7	62.6	33.6	13.2	65.8
	0	30.8	63.1	34.3	11.8	54.2
1963-64	90	32.2	60.9	29.9	14.2	64.3
	60	35.7	61.3	29.8	14.1	63.2
	30	32.9	61.4	29.3	13.8	62.8
	0	30.1	61.8	29.6	13.0	58.4
Averages	90	29.3	59.7	31.6	15.3	68.2
	60	31.1	60.1	31.2	14.8	67.5
	30	30.4	60.4	30.5	14.0	66.0
	0	28.7	60.3	31.0	13.0	60.7

plots indicate a need for additional N for the production of quality wheat. In 1963-64, a year of optimum moisture and growing conditions, there was no significant yield response to N. However, additional N improved the protein quantity and quality of wheat grown at Idaho Falls, Table 11.

The plots located 8 miles east of Fairfield, Table 12, were harvested each of the 4 years in this study. A modest but nonsignificant increase in yield was produced each year by the 30-pound N rate. The 60-pound rate produced significant yield increases in 1961-62, and in 1963-64. In 1962-63 Fairfield experienced the heading to harvest drought as did most of the other areas in the study, but the 90-pound N rate returned the highest yields — contrary to the results at the other locations. Protein quantity and quality was slightly below the desired level during that season at the check rate. In the other crop seasons quality levels were good at all N levels; there was a significant increase in quality from each increased application of N.

RATE AND DATE OF SEEDING

An additional study was initiated in the fall of 1960 to determine the effect of rate and date of seeding and nitrogen fertilizer on the quality of hard red winter wheat. Roy, Weston, and Rexburg were selected as appropriate locations. Seeding rates of 20, 40, 60, and 80 pounds of Itana per acre were planted at 5 average seeding dates: August 4 and 19, September 4, 15 and 29. Two early seeding dates, July 2 and 25, were included at Weston in the fall of 1963. The 0, 30, 60, and 90 pound per acre N treatments were applied broadcast on the first seeding date. The seeding rates were not replicated; one 270 foot, 8-row area was planted at each rate on each date. Locations were to be used as replications, but only in 1961-62 was more than one location harvested. In 1960-61, only the plot at Roy survived. In 1961-62, plots at Roy and Weston were harvested. In 1962-63 the plot was at Rexburg, and at Roy in 1963-64.

Stand establishment and survival were the major difficulties encountered in the rate-and-date of seeding study. Early seedings favored with available soil moisture establish themselves rapidly and produce lush growths which became susceptible to destructive factors such as snow mold, stripe rust, wheat streak mosaic, and root and foot rot complexes. The 1963-64 plot at Weston was lost to these conditions. Late plantings in some areas were made in relatively dry soil with poor emergence and establishment resulting. This was especially true at Weston where the surface to 6-inch soil moisture tends to disappear by about mid-July. Available moisture levels in the soil surface are again attained when the fall rains occur, which quite often is too late for maximum emergence and stand establishment.

Table 13 shows the averages of all the plots and years harvested in the rate-and-date of seeding study. These data show that when comparing seeding rates, the 60-pound rate produced the highest yields and test weight, although never significant statistically at any location in any year. The highest average response to protein percent, sedimentation, and farinograph peak was at the 40-pound seed rate. The 60- and 80-pound seed rates at Rexburg in 1962-63 produced signficantly lower protein at the 1 percent level than the 20- and 40-pound rates. This quality response was also found in the sedimentation values, where the 20-pound rate produced significantly higher values at the 1 percent level than did the 60- or 80-pound rate, although no different than the 40-pound rate.

When comparing seeding dates, it is apparent that the highest yields and test weights were obtained with the earliest seeding date, and steadily decreased thereafter as the seeding date was delayed. The highest quality characteristics were obtained at the later seeding dates.

The N rate effect has been significant only for protein increase and then only for one year and for one location: Roy in 1961. In that year, the 90-pound N rate produced significantly higher protein than did the check plot.

The statistical significance of the data in this study has been impaired by the lack of plot survival, and the relatively small volume of data to be evaluated. However, Table 13 with its averages would closely proximate the recommendations felt to be valid based on the limited data.

Table 13. Rate and date of seeding data, an average of the results of five plots in 1961, 1962 and 1963 at three locations, Roy, Weston and Rexburg

	Yield bu/acre	Test lb/bu	Protein %	Sedimentation	Farinograph peak min.
Seed rate					
20	28.5	58.8	12.7	52.7	9.7
40	30.9	59.8	13.1	53.8	10.6
60	31.9	60.0	12.6	49.4	9.4
80	31.3	59.8	12.6	48.9	9.6
Seed date					
Aug. 4	34.0	60.3	11.7	43.8	7.3
Aug. 19	32.7	60.1	12.3	49.3	8.5
Sept. 4	29.0	59.0	13.1	53.9	11.3
Sept. 15	28.2	59.3	13.9	60.3	11.1
Sept. 29	30.6	59.4	13.7	37.0	11.0
N rate					
90	29.9	58.3	14.6	66.3	11.7
60	31.8	59.1	13.3	57.7	11.5
30	30.9	60.4	12.1	44.3	8.6
0	29.8	60.6	11.1	36.5	7.5

5M TP9888 4-66

AGRICULTURAL RESEARCH FOR IDAHO

UNIVERSITY OF IDAHO
COLLEGE OF AGRICULTURE EXPERIMENT STATION

MOSCOW—Home Station. 1,100 acres; Elevation 2,564 feet; Established 1892. Basic and Applied Research in all fields.

SANDPOINT — Branch Station. 98 acres; Elevation 2,100 feet; Established 1912. Research on The Cut-over Lands of Northern Idaho.

LEWISTON—Field Station. 22 acres; Elevation 1,413 feet; Established 1948. Basic and Applied Research on Fruits and Vegetables.

PARMA—Branch Station. 60 acres; Elevation 2,274 feet; Established 1935. Onion and Carrot Hybrids, plus research on other vegetables and fruits.

CALDWELL — Branch Station. 320 acres; Elevation 2,375 feet; Established 1906. Beef, Dairy Cattle and Sheep Nutrition and Management Research.

TWIN FALLS — Branch Station. 80 acres; Elevation 3,745 feet; Established 1950. The "Bean" Station with Research on New Varieties and Cultural Practices.

ABERDEEN — Branch Station. 238 acres; Elevation 4,400 feet; Established 1911. Potato Varieties, Disease and Storage and Cereal Grain Research, Wheat Quality Lab also located here.

TETONIA — Branch Station. 590 acres; Elevation 6,200 feet; Established 1919. Production and Maintenance of Foundation Seed Stocks of Grains, Grasses and Potatoes.

DUBOIS — U.S. Sheep Experiment Station - Western Sheep Breeding Lab. Established 1915. Nutrition Research and Breed Improvement—U. of I cooperating.