FERTILIZER RECOMMENDATIONS

For Wheat in the Columbia Basin of Oregon

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Contents

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More detailed data reporting the experiments on which these recommendations are based may be found in OSU Agricultural Experiment Station circulars of information 570 and 607 and technical bulletin 57, available in libraries or county Extension offices.

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Fertilizer Recommendations for Wheat In the Columbia Basin of Oregon

In the early 1950's wheat farmers in the Columbia Basin of Oregon began using nitrogen fertilizers in limited amounts. With the help of the agricultural experiment stations at Moro and Pendleton, they soon learned that the addition of nitrogen would give increased yields of wheat even in areas of limited rainfall. When gaseous and liquid nitrogen materials were introduced into this area, the price of nitrogen fertilizers dropped materially and their use expanded to all wheat producing counties.

The experiment stations at Pendleton and Moro have been conducting research on rate, method, and time of application of nitrogen fertilizer materials for many years. In 1953 a cooperative program for off-station fertility testing was developed, utilizing the services of the Soil and Water Conservation Research Division, Agricultural Research Service, United States Department of Agriculture; the Oregon Agricultural Experiment Station; and the Oregon Cooperative Extension Service. During the 4-year period, 1954 to 1957, 171 experiments were conducted in the five major wheat producing counties of the Columbia Basin of Oregon.

Attempts were made to locate the experimental sites on all major soils and under all of the varied climatic conditions of the area.

Soils Studied

Approximate soil areas and locations of experimental sites are indicated in Figure 1. The soils used most extensively for wheat production are Walla Walla, Ritzville, Condon, and Morrow. Other soils of lesser extent are Athena, Pilot Rock, McKay, and Tub. Most of these soils were developed from loess (wind blown) materials, but the depth and development of their profiles varies widely owing to the effects of climate and other factors. Also there may be variation in the depth, texture, and water holding capacity within individual soil series.

Characteristics of each of the soils studied as they are reflected in wheat yields will be discussed later.

Climate of Area

Average annual rainfall of the Columbia Basin area is approximately 8 inches near Boardman on the Columbia River in northern Morrow County and increases as the elevation increases in every direction toward the mountains. The Cascade Mountains lie to the west, the Ochoco Mountains to the south, and the Blue Mountains to the south and east. The general rainfall pattern for the wheat-producing area is shown in Figure 2.

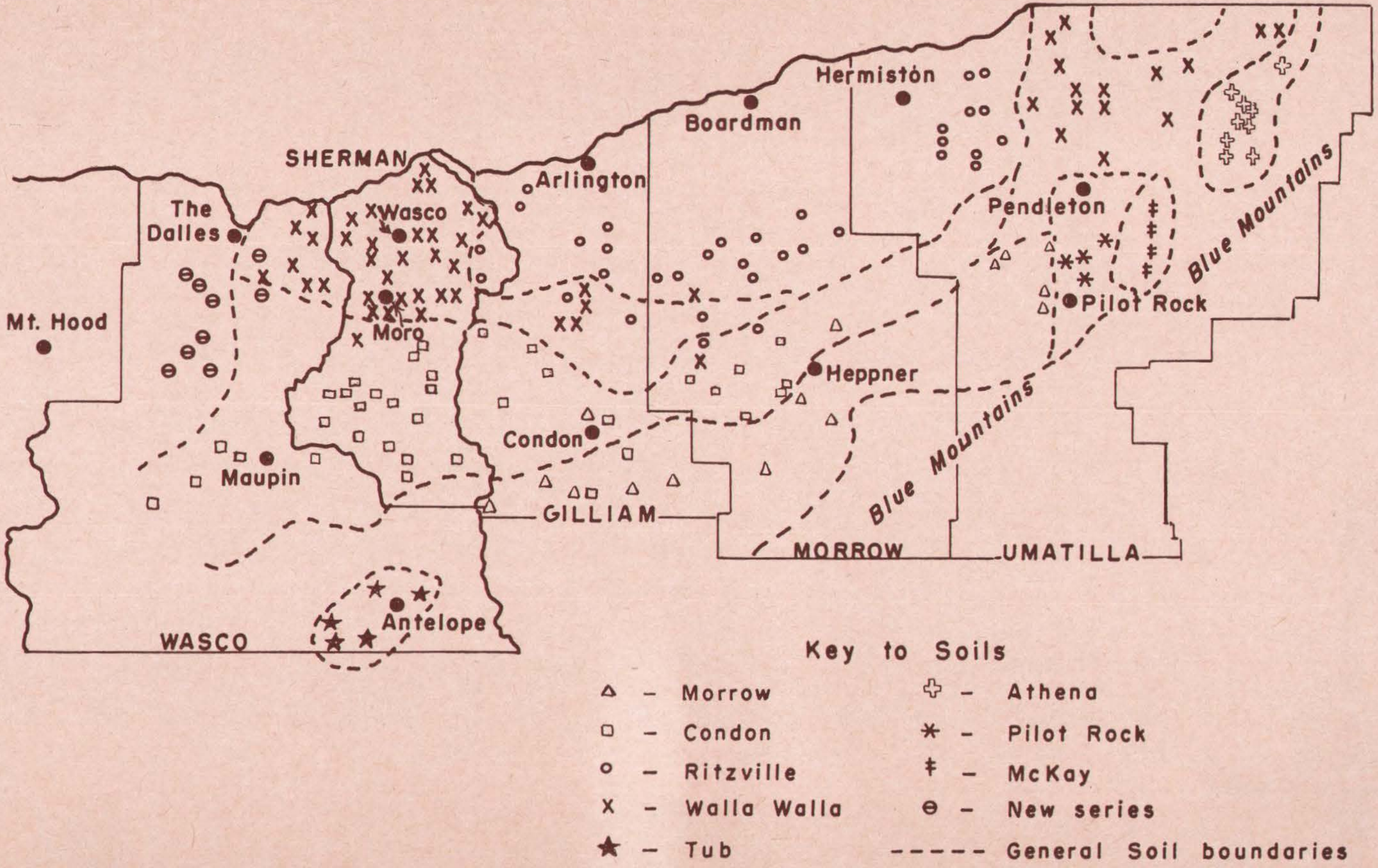


Figure 1. Approximate location of experimental sites.

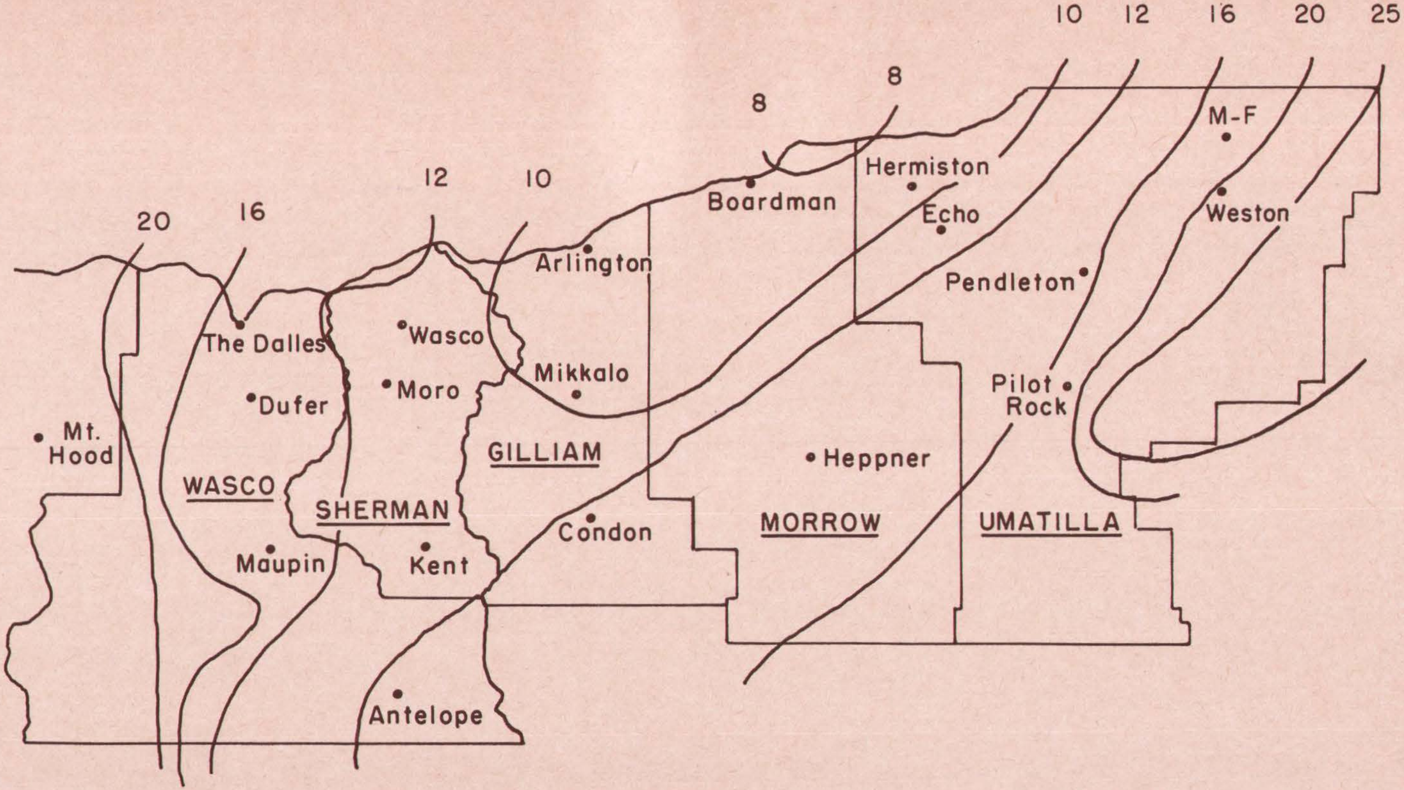


Figure 2. Approximate average annual precipitation, inches per year.

Experimental Procedure

Of the 171 experiments, 152 were on farms in an area of less than 15 inches of annual rainfall where a wheat-fallow system was practiced. The remainder were located in an area of over 15 inches rainfall where land is cropped annually, often alternately with wheat and canning peas. Selection of each site was made on the basis of its representation of the soil series, apparent uniformity, past management, degree of slope, and proximity to roads. In general, slopes of over 5% were avoided because of problems related to the conduct of the experiments.

Farmers selected as cooperators prepared seedbeds, planted wheat, sprayed weeds, and performed other necessary field operations on the experimental sites except application of fertilizer treatments and harvest of plots.

In the lower rainfall area nitrogen was added at rates of 0, 20, 40, 60, 80, and 100 pounds of nitrogen per acre. Rates were 50% higher in the higher rainfall area. Phosphorus and sulfur were added the first year, but as there was no indication that they contributed to yield increase they were discontinued. To some plots at each site, nitrogen fertilizer was applied in the fall at seeding time; to others, it was applied as a top dressing in the spring shortly after growth started. To overcome some of the soil variability within the boundaries of an experimental site, four replications of fertilizer treatments were used. Self-propelled portable plot combines were used to harvest experimental plots.

Results and Discussion

Equally good responses from nitrogen applied in fall or spring were obtained on about two-thirds of the sites; on the remaining third there were approximately equal numbers of cases of superiority of fall-applied and spring-applied nitrogen. For this reason, all results given in this bulletin refer to fall-applied nitrogen. Yield response of wheat to application of nitrogen on experimental sites is shown in Table 1. Of the 171 experiments conducted, significant yield increases from nitrogen occurred on 125 sites. There was a significant yield decrease on 22 sites, and on 24 sites nitrogen had no effect. Most sites showing a decrease were located on shallow soils where moisture was the limiting factor and, because of early exhaustion of the moisture supply, addition of nitrogen indirectly resulted in "burning" of foliage and shriveling of grain. Half of the experiments which showed a decrease or no change in yield with added nitrogen did so in 1955—a dry year.

Table 1. Yield responses occurring on experimental sites as a result of nitrogen fertilization

Year	Number of experiments for which the following type of yield response occurred		
	Increases	Decreases	No change
1954	36	4	8
1955	25	12	10
1956	39	0	3
1957	25	6	3
Total	125	22	24

Results from nitrogen fertilizer experiments for each of the four major soil series (Morrow, Condon, Ritzville, and Walla Walla) are presented in the following sections. This information will be given in terms of actual yield of grain produced in bushels per acre. An increase in yield is referred to as a "response" to nitrogen and is used in that sense throughout this bulletin. The reason for using "response" rather than actual yield is that general yield levels vary from year to year depending on many factors, very few of which can be controlled. However for each year, whether good or bad, response to nitrogen fertilizer can generally be measured by noting the difference in yield from the check (or zero N) treatment.

With the discussion of results of the experiments on each soil series, a suggested recommendation for the use of nitrogen fertilizer is given. This is based largely on experimental results and, in part, on general knowledge of the soils and other factors contributing to production of wheat in the area. Unless otherwise noted, recommendations are for a wheat-fallow cropping system.

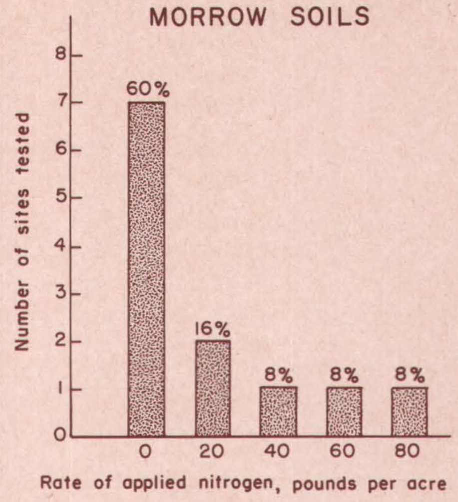


Figure 3. Number of sites and rates of nitrogen producing maximum yields on Morrow silt loam.

Morrow Soils

Depth of these soils ranged from 2 to 2½ feet. Rainfall averages from 12 to 15 inches per year, which is usually sufficient to wet the entire profile during the winter months. The number of experiments on Morrow silt loam and the number which gave an increase in yield with each level of added nitrogen are shown in Figure 3. Of the 12 experiments conducted, 7 gave maximum yields without nitrogen, 2 with rates of 20, and 1 each with 40, 60, and 80 pounds of nitrogen per acre. Four of the five experiments which responded to added nitrogen did so in 1956, the year of the highest spring moisture in these soils. Average yields for all plots indicated that lack of moisture storage due to the shallow depth of these Morrow soils was perhaps the limiting factor in wheat production.

Although only 40% of the experimental sites gave a response to added nitrogen the year of application, an increase in yield occurred on some of these plots the following crop year when no additional nitrogen was applied. This increases the odds that some nitrogen may be beneficial for production of wheat on these soils.

Suggested use of nitrogen

Under average moisture conditions, maximum yields are generally obtained without the use of nitrogen. In seasons of above-average spring rainfall or where above-average stored soil moisture occurs, good responses can be expected from 20 to 40 pounds of spring-applied nitrogen.

Condon Soils

Over the 4-year period 32 experiments were conducted on Condon silt loam. Condon sites ranged in depth from 2 to 5 feet in a 10 to 14 inch rainfall area. Response to added nitrogen was closely correlated with depth. Figure 4 clearly indicates that the majority of the shallow sites (2 to 3 feet) did not respond to added nitrogen, but all those that were deeper (over 3 feet) responded. This is probably explained by differences in stored soil water. Data in Table 2 indicate that the deeper Condon soils contained about 50% more water in the fall and about 80% more water in the spring than did the shallower soils. For the deeper sites where moisture was more abundant, nitrogen was an important factor in the production of wheat. In the first group only 30% responded to added nitrogen, while in the second group 70% responded to 20 pounds of added nitrogen and the remainder to 40 pounds. The majority of the shallower soils which responded to an application of nitrogen did so in 1956.

Of the large number of sites on the shallow soils that did not respond to applied nitrogen the year of application, many will undoubtedly respond to residual nitrogen the next crop year. This may also be true of the sites on deeper soils that responded to only 20 pounds of nitrogen.

Figure 4. Number of sites and rates of nitrogen producing maximum yields on Condon soils.

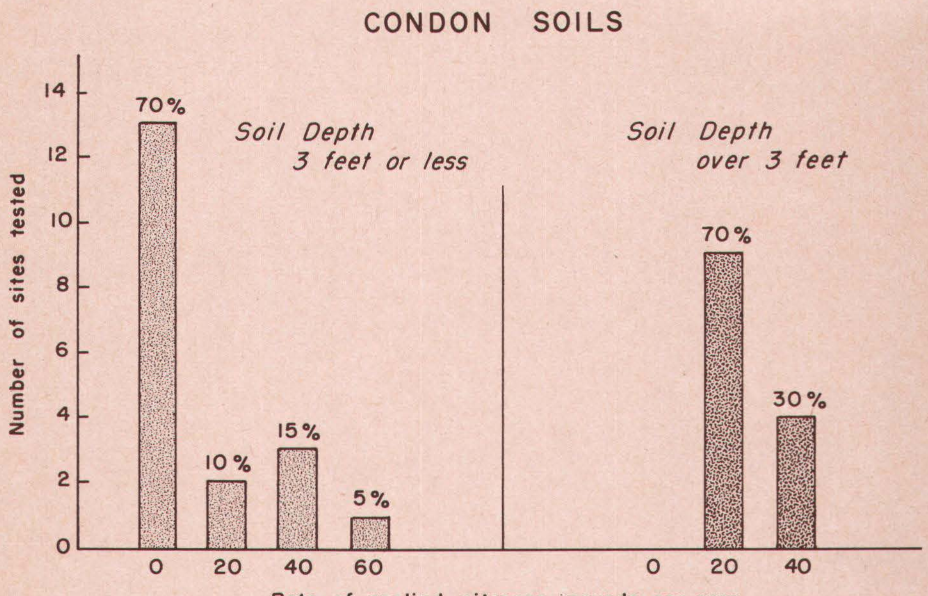


Table 2. The relationship of soil depth to yield and fall and spring soil moisture on Condon and Ritzville sites

Soil depth	Number of sites	Average maximum yield	Average fall soil moisture	Average spring soil moisture
		Bu/A	*Inches*	*Inches*
Condon				
2 to 3 feet	19	28	2.9	3.9
Over 3 feet	13	44	4.2	7.0
Ritzville				
Less than 5 feet	14	23	2.5	4.5
5 feet or more	20	30	3.1	6.0

Suggested use of nitrogen

Where Condon soils are 3 feet or less in depth, maximum yield can be obtained in most cases without addition of nitrogen fertilizer. In very favorable moisture years, 20 to 40 pounds of nitrogen could be applied with good results.

On the deeper Condon soils one can normally expect maximum yields with 20 to 40 pounds of added nitrogen.

Ritzville Soils

There were 34 experiments conducted on Ritzville soils during the 4-year period. Soil depth of these sites ranged from 2½ to over 6 feet to underlying bedrock or restrictive layer. Response to nitrogen fell into two distinct depth groups—those under 5 feet and those 5 feet and over. Figure 5 shows that the majority (86%) of maximum yields on the shallow soils were with rates of either none or 20 pounds of added nitrogen. No significant increases in yield were noted at any rate of nitrogen above 40 pounds. It should again be pointed out that where a limited effect of nitrogen was seen on these shallow soils the year of application, a good response may show up the next crop year.

Wheat grown on the deeper sites responded to all rates of added nitrogen, with the largest response group at the 40-pound rate. The total for the 40-pound and 60-pound rates accounted for 75% of the maximum yields.

Table 2 shows that yields averaged 30% higher on the deeper soils than on the shallower soils; 30 bushels per acre for the deeper and 23 bushels per acre for the shallower soils. The deeper soils were also shown to contain 13% and 33% more water in the fall and spring, respectively, than did the shallow soils. This increased moisture storage capacity is probably the major reason that higher yields were obtained on these soils.

Suggested use of nitrogen

Under normal moisture conditions 20 pounds of nitrogen will be adequate for Ritzville soils less than 5 feet deep. For years of below average moisture no nitrogen should be needed.

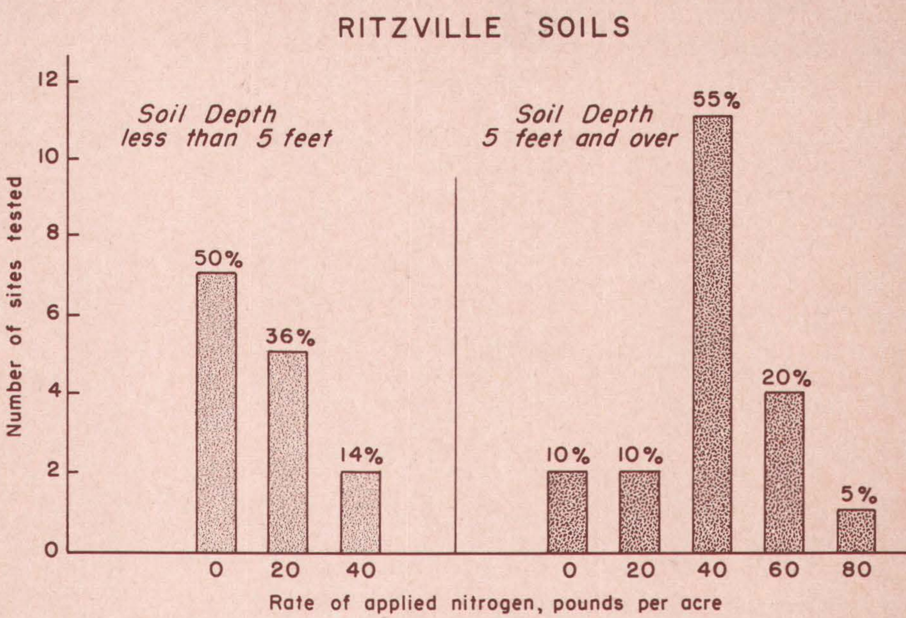


Figure 5. Number of sites and rates of nitrogen producing maximum yields on Ritzville soils.

The deeper (5 feet and over) Ritzville soils will require from 40 to 60 pounds of added nitrogen for maximum yield when moisture is adequate. However, for years of low rainfall the amount of nitrogen should be reduced.

Walla Walla Soils

There were 45 experiments on Walla Walla soils. Twenty-three of these were on soils referred to as Walla Walla silt loam. These included both of the major map units shown in the soil survey of Umatilla County and the Walla Walla silt loam units in the soil survey of Sherman County. Twenty-two were on soils referred to as Walla Walla coarse silt loam. These included the soils at the low rainfall (dry) end of the climatic range and the coarse end of the textural range as recognized in the Sherman County soil survey. Figure 6 shows the number of sites and the rates of added nitrogen where maximum yields were obtained for each of the two Walla Walla soil groups.

Half of the experiments on Walla Walla silt loam produced maximum yields of wheat when 40 pounds of nitrogen were applied. The 40- and 60-pound rates together accounted for 80% of the maximum yield plots.

Nitrogen added to Walla Walla coarse silt loam gave maximum yields on 12 out of 22 sites with the 20- and 40-pound rates of nitrogen. At least three sites produced maximum yields at each of the 0-, 60-, and 80-pound rates of nitrogen.

Suggested use of nitrogen

Maximum wheat yields will be obtained, in years of normal moisture, with the application of 40 to 60 pounds of nitrogen on Walla Walla silt loam, and 20 to 40 pounds of nitrogen on Walla Walla coarse silt loam soils. Higher or lower rates can be added depending on extremity of moisture conditions.

Athena Soil

Wheat is grown following peas or barley on Athena soil, so production and fertilizer needs are quite dependent upon past management.

Suggested use of nitrogen

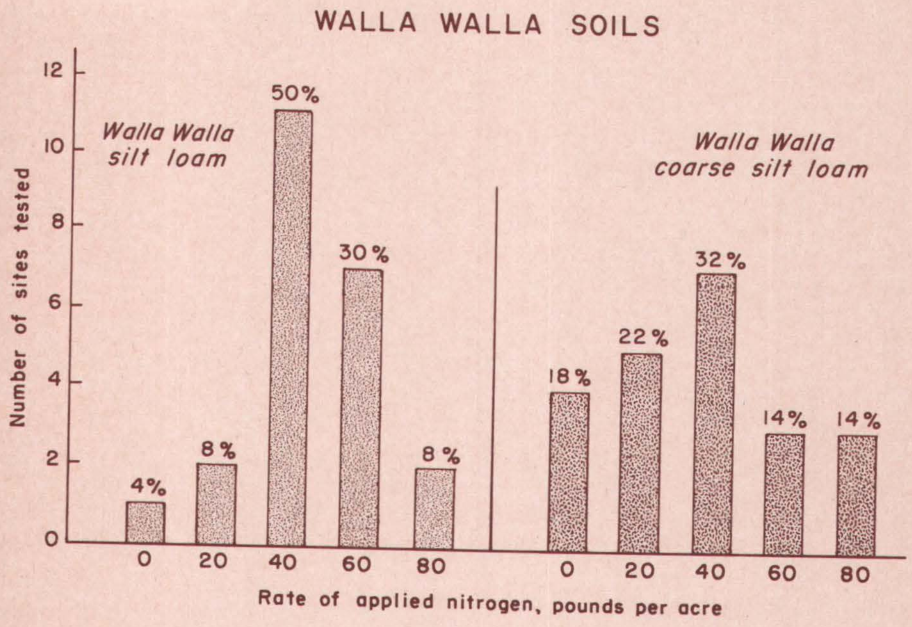
When wheat follows peas, 30 to 60 pounds of nitrogen should be applied. For continuous grain, 60 to 120 pounds of nitrogen per year are recommended.

Other Soils

Due to limited research data on other soils, only an average range of nitrogen rates is given below. These are the ranges in which the largest number of experiments produced maximum responses to added nitrogen. Wheat is grown on all of these soils after fallow.

Pilot Rock .... None to 20 lbs. of N per acre
McKay .... 20 to 40 lbs. of N per acre
Tub .... 20 to 40 lbs. of N per acre

Figure 6. Number of sites and rates of nitrogen producing maximum yields on Walla Walla soils.



Factors Affecting Wheat Yields

Factors which affect production of wheat are many and varied. Some of the most important ones are discussed briefly below.

Residual nitrogen effect

The amount of nitrogen applied to a given crop may not be fully utilized the year of application. The unused portion of this fertilizer may remain in the soil through the fallow period as residual nitrogen to be taken up and used by the next crop. It was shown[1] in eight locations on Walla Walla silt loam that average response to residual nitrogen was approximately one-third that obtained for the first crop. At nine sites on Ritzville silt loam carry-over of nitrogen from one crop year to the next gave an average increase in yield equal to that of the first crop. On Condon soils, where response to nitrogen may be small, residual effect was even more pronounced in three locations. For three sites on Morrow soil response to residual nitrogen was great enough to compensate for the reduction in yield that resulted from nitrogen fertilization of the first crop.

When a field has a history of repeated use of high rates of nitrogen, it may be economical to make a downward adjustment in the general fertilizer recommendations to compensate for this carry-over effect.

Residue management

When heavier than average amounts of wheat stubble are returned to a soil, it is often necessary to add additional nitrogen to prevent a depression in yield. Usually 10 to 20 pounds of nitrogen per acre will overcome this depressing effect.

Precipitation

Amount and distribution of rain and snow govern to a large degree the amount of soil moisture and subsequent response from use of fertilizers. Even in years of normal precipitation, soil moisture may be limiting because rain or snow falls on frozen ground during the winter and is lost by runoff. Rain distribution must be considered, particularly in the spring.

Soil depth

The deeper a soil, the more moisture it can store for crop needs. Shallow soils, even though they become saturated in the winter, may run out of moisture before the crop is fully matured. This may result in no increase in yield from applied nitrogen or a depression in yield if the fertility level is too high in relation to available moisture.

Soil textures

Textures also effect the moisture storage capacity of a soil. Coarse textured soils, even though deep, may have less total moisture storage capacity than shallower, fine-textured soils. This must be kept in mind, particularly when predicting nitrogen fertilizer needs for different textured soils of the same soil series.

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[1] Charles M. Smith. *Residual nitrogen response with wheat in eastern Oregon.* Proceedings, Tenth Annual Fertilizer Conference of the Pacific Northwest, Tacoma, Washington. July 7-9, 1959.

Crop rotation

Some farmers are following a crop rotation system that includes alfalfa, sweet clover, peas, or other legumes. When a legume crop is plowed under and the land returned to wheat production, it is usually not necessary to add nitrogen fertilizer for the first three crops, after which rates can be gradually increased. Experimental results indicate that some effects will be visible for at least six subsequent wheat crops.

Other essential plant food elements

Plant food elements other than nitrogen may be limiting to the extent that nitrogen will not give maximum yield increases. Farmers should determine by means of soil tests or field trials whether phosphorus fertilizer is needed. In some areas sulfur deficiency symptoms have been noted. Field-strip trials should be employed to determine the need for sulfur or other plant nutrients.

Effect of Nitrogen on Wheat Quality

Wheats grown on these experiments were of the soft white varieties whose milling quality would have been impaired if their protein contents had risen to undesirable levels. On plots where added nitrogen increased yields significantly, protein content stayed below 10% until more nitrogen was applied than was needed for maximum yields. Where nitrogen decreased or had no effect on yield, protein content markedly increased above 10% with each increment of nitrogen.

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