BULLETIN 553

OCTOBER 1983

Fall - Spring Nitrogen Combinations for Wheat Grain Production

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FIRST PRINTING 5M, OCTOBER 1983

Fall - Spring Nitrogen Combinations for Wheat Grain Production

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INTRODUCTION

NITROGEN FERTILIZER efficiency is defined as the percentage of applied N used by the current crop. For many nonleguminous crops, including wheat, N efficiency will generally average between 40 and 60 percent. The relatively low N fertilizer efficiency is often due to N losses through various mechanisms, such as leaching and denitrification, and unavailability through immobilization. Leaching and denitrification losses are directly related to excessive rain and wet soils. Unavailability due to immobilization results from low N-containing crop residues, such as grain sorghum and corn stalks.

Frequent rains and continuously wet soils, which are common during the winter months in the Southeast, create conditions favorable for poor N efficiency. To help avoid poor efficiency of N applied to wheat, split N applications are commonly recommended. Generally, one-fourth to one-third of the N fertilizer is applied at planting (20 to 30 pounds per acre N), and the remainder (60 to 80 pounds per acre) is applied in late winter or early spring just prior to the period when wheat begins to take up large quantities of N. The second application of N probably should correspond with early jointing, which generally occurs between early February and early March in Alabama and Georgia.

The quantity of available N (ammonium and nitrate) in the

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soil, and the quantity of unavailable N (primarily organic N) that will be released to the available form during the growing season depends on the previous summer crop. If the previous summer crop is a legume, such as soybeans, relatively large quantities of high N residues may be left in the field after harvest. High N residues degrade fairly rapidly and will often supply some N during late fall or early winter. If the previous summer crop is a high N efficient nonleguminous plant, such as grain sorghum, soil N levels at sorghum harvest will probably be low. In addition, the sorghum residues left in the field are generally low in N (less than 1 percent N), and can immobolize soil N. Theoretically, 3,000 to 6,000 pounds of sorghum residue will immobilize 30 to 60 pounds of plant available N.

In the Southeast, wheat harvested for grain is commonly grown in double-cropping systems. Most of the wheat is double cropped with soybeans, but considerable acreage is double cropped with nonleguminous crops, such as grain sorghum, cotton, and corn. Since the fertilizer N requirements for wheat following legumes may be less than the requirement for wheat following nonlegumes, N fertilizer recommendations for wheat probably should be related to the previous crop. The primary objective of this study was to determine if N fertilizer recommendations for wheat should depend on the previous summer crop. Other objectives were to determine optimum fall-spring N combinations, and to determine if soil or tissue N levels could be used as an indication of fertilizer N requirements.

MATERIALS AND METHODS

These studies were conducted for 4 years (1977-81) at the University of Georgia's Southwest Georgia Branch Experiment Station (Plains) and Northwest Georgia Branch Experiment Station (Calhoun), and for 2 years (1980-82) at Auburn University's Sand Mountain Substation (Crossville), Prattville Experiment Field (Prattville), and Wiregrass Substation (Headland). Classification of soils at each location is listed in table 1. Except for N, which was a treatment variable, fertilizer and lime applications were based on soil test recommendations.

The first wheat crop followed soybeans at Calhoun and grain sorghum at Plains. In subsequent years, wheat followed soybeans and grain sorghum at each location. Sorghum and soybean areas were adjacent and were alternated annually. Each year, grain

TABLE 1. CLASSIFICATION OF SOILS AT EACH LOCATION

Location	Series	Surface texture	Subgroup
Plains	Greenville	Sandy clay loam	Rhodic Paleudults
Calhoun	Cedarbluff	Silt loam	Fraqiaquic Paleudults
Crossville	Hartsells	Fine sandy loam	Typic Hapudults
Prattville	Lucedale	Sandy clay loam	Rhodic Paleudults
Headland	Dothan	Fine sandy loam	Plinthic Paleudults

sorghum was sidedressed with 80 pounds per acre N (prilled ammonium nitrate) 2 to 4 weeks after emergence. Nitrogen was not applied to the soybeans.

After soybean and sorghum harvest in late October or November, the soil was tilled and wheat was drilled (6 $\frac{2}{3}$-inch row spacings) at a seeding rate of 90 pounds per acre. Variety and planting dates are listed in table 2.

Fertilizer N treatments consisted of fall-spring combinations. Fall N rates were 0, 10, 20, 30, and 40 pounds per acre in Georgia, and 0, 12, 24, and 36 pounds per acre in Alabama. Spring N rates were 0, 20, 40, 60, and 80 pounds per acre in Georgia, and 0, 24, 48, and 72 pounds per acre in Alabama. Prilled ammonium nitrate was the N source. Fall N was applied at planting or shortly after planting, and spring N was applied between mid-February and mid-March, table 2. Fall and spring N treatments were arranged in a complete factorial within a randomized complete block design replicated four times.

Data collected included soil and tissue N levels (Kjeldahl

TABLE 2. WHEAT VARIETY, PLANTING DATE, AND SPRING N APPLICATION DATE FOR EACH YEAR AND LOCATION

Year	Location	Variety	Planting	Spring N
1978	Calhoun	Ga. 1123	11-01-77	03-16-78
	Plains	Oasis	11-28-77	03-06-78
1979	Calhoun	Oasis	11-21-78	03-14-79
	Plains	Oasis	11-17-78	02-14-79
1980	Calhoun	Oasis	11-15-79	02-25-80
	Plains	Omega 78	11-29-79	02-05-80
1981	Calhoun	McNair 1813	11-12-80	03-03-81
	Plains	McNair 1813	12-04-80	02-26-81
	Crossville	Coker 747	10-23-80	03-02-81
	Prattville	McNair 1813	10-24-80	03-03-81
	Headland	Coker 762	11-27-80	02-24-81
1982	Crossville	Coker 762	11-09-81	03-04-82
	Prattville	Coker 747	11-02-81	02-20-82
	Headland	Coker 762	11-05-81	02-24-82

procedure) just prior to spring N applications and grain yields at maturity. Wheat was harvested with a combine and grain yields were adjusted to a test weight of 60 pounds per bushel at 13 percent grain moisture. Statistical analyses used to separate treatment means included analysis of variance, appendix table, least significant differences at the 10 percent level of probability, and multiple regression.

RESULTS AND DISCUSSION

Optimum N rate and combination varied among location, previous crops, and years. As a result of variability associated with yields even within previous crops, locations, and years, it is difficult to select an optimum N rate or combination. In this report, suboptimum N rates and combinations were determined at the 10 percent level of probability. Any yield value significantly less than the absolute highest yield is considered to be suboptimum. Yield values not significantly less than the absolute highest are considered to be equal to the highest yield. In the remainder of this report, fall and spring N treatments will be indicated by giving pounds per acre fall N-pounds per acre spring N. For example, a 10-40 N treatment represents 10 pounds per acre fall N and 40 pounds per acre spring N.

Fall-applied N and Yields

Although fall-applied N appeared to be critical for optimum yield in some experiments, tables 3-5, the data indicate that fall N cannot be substituted for spring N. Only in 1 of the 24 experiments did fall N without spring N result in optimum yields. The one exception occurred at Headland in 1981 when soybeans were the previous crop, table 5. In three of the experiments where low rates of spring N without fall N resulted in optimum yields (Calhoun in 1980 and 1981, table 4; and Plains in 1979, table 3), equal or higher rates of fall N without spring N did not result in optimum yields. Each of these three situations occurred when soybeans were the previous crop.

Fall-applied N was required for optimum yield in 8 of the 24 experiments. Requirements for fall N occurred three times when wheat followed soybeans (Plains in 1980, table 3; and Crossville and Prattville in 1981, table 5), and five times when wheat followed grain sorghum (Plains in 1979 and 1980, table 3; Calhoun in 1981, table 4; and Crossville and Headland in 1981, table 5).

TABLE 3. WHEAT GRAIN YIELDS AT PLAINS, GEORGIA, AS AFFECTED BY PRECEDING CROPS AND APPLIED NITROGEN

Spring N, lb./acre	Yield/acre, by previous crop and fall N, lb./acre									
	Soybeans					Grain sorghum				
	0	10	20	30	40	0	10	20	30	40
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
1978										
0						18	22	23	22	27
20						25	28	27	28	29
40						26	29	27	32	33
60						31	31	30	30	32
80						32	31	31	34	30
1979										
0	31	28	40	44	41	4	7	12	12	24
20	47	47	45	49	58	14	14	28	28	29
40	48	52	46	54	52	21	30	39	37	39
60	50	48	54	49	55	34	35	45	43	51
80	51	51	48	50	51	40	48	52	45	55
1980										
0	29	25	25	32	36	22	22	31	36	35
20	29	28	34	37	41	27	29	31	40	44
40	35	40	34	42	43	32	37	36	42	47
60	44	47	41	48	49	38	44	45	42	50
80	43	50	51	52	53	45	53	51	53	50
1981										
0	45	50	48	55	58	27	27	34	55	52
20	52	57	55	56	62	42	54	53	52	64
40	55	63	56	62	65	52	53	45	53	66
60	60	61	64	62	64	49	58	59	64	57
80	65	61	64	63	58	58	65	60	62	68

Values located within the shaded area are not statistically lower ($P \leq 0.10$) than the absolute highest yield.

In each of these eight experiments, the lowest rate of fall-applied N (10 to 12 pounds per acre) was sufficient for optimum yield. In four of the eight experiments, however, the lowest rate of fall-applied N did not result in the least amount of total N (fall + spring) needed for optimum yield. These responses occurred when sorghum was the preceding crop at Plains in 1979, table 3, and Crossville in 1981, table 4, and when soybeans preceded wheat at Crossville and Prattville in 1981, table 4. The 10-80 combination (90 pounds per acre total N) resulted in 48 bushels of wheat per acre and the 20-60 combination (80 pounds per acre total N) resulted in 45 bushels at Plains. Similar responses were obtained with the other three experiments.

In addition to the eight experiments where fall N was required for optimum yields, there were seven experiments where the use of fall N reduced the total N fertilizer requirements for optimum yield. This response occurred with both previous crops at Plains in 1981, table 3, and Calhoun in 1980, table 4; with soybeans at Prattville in 1982, table 5; and with sorghum at Prattville in 1981 and at Headland in 1982. At Plains, the 0-80 combination (80 pounds per acre total N) resulted in 58 bushels per acre wheat yields while the 40-20 combination (60 pounds N) resulted in 63 bushels when wheat followed sorghum. The same relationships were found with the other six experiments, which suggests that the use of fall N may reduce total fertilizer N requirements even though optimum yields may be obtained without any fall-applied nitrogen.

In summarizing wheat yield responses to fall N, there was a beneficial effect of fall N in 15 of the 24 experiments. In 8 of these 15 experiments, fall N was required for optimum yield regardless of spring N rate; three responses occurred when soybeans were the previous crop and five occurred when sorghum was the previous crop. In the other seven experiments, fall N was not required for optimum yield, but applying fall N allowed significant reductions in the amount of spring N needed, thus

TABLE 4. WHEAT GRAIN YIELDS AT CALHOUN, GEORGIA, AS AFFECTED BY PRECEDING CROPS AND APPLIED NITROGEN

Spring N, lb./acre	Yield/acre, by previous crop and fall N, lb./acre									
	Soybeans					Grain sorghum				
	0	10	20	30	40	0	10	20	30	40
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
1978										
0	33	33	32	41	47					
20	37	36	42	35	44					
40	44	38	46	51	55					
60	49	49	57	44	63					
80	58	56	49	48	55					
1980										
0	26	27	34	34	39	24	25	31	32	38
20	34	40	37	43	43	23	30	35	37	40
40	40	45	42	45	41	37	39	42	43	41
60	43	42	40	45	42	43	45	43	45	43
80	43	42	38	34	39	36	42	39	38	40
1981										
0	38	46	48	52	60	23	31	43	40	47
20	50	59	57	54	61	34	35	49	50	48
40	66	55	56	56	67	45	58	59	56	61
60	70	67	66	62	70	62	53	58	65	69
80	71	68	67	64	61	60	64	64	71	71

Values located within the shaded area are not statistically lower ($P \leq 0.10$) than the absolute highest yield.

TABLE 5. WHEAT GRAIN YIELDS AT CROSSVILLE, PRATTVILLE, AND HEADLAND, ALABAMA, AS AFFECTED BY THE PREVIOUS CROP AND APPLIED N

Spring N, lb./acre	Yield/acre, by previous crop and fall N, lb./acre							
	Soybeans				Grain sorghum			
	0	12	24	36	0	12	24	36
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Crossville 1981								
0	31	38	38	34	14	21	24	28
24	42	42	45	46	27	31	37	39
48	38	47	51	45	38	40	42	46
72	43	46	45	45	40	44	47	53
Crossville 1982								
0	20	23	23	24	2	4	4	4
24	31	26	28	26	17	15	18	15
48	30	34	33	38	23	21	23	14
72	28	28	32	29	21	27	21	22
Prattville 1981								
0	35	41	47	58	44	66	66	64
24	50	62	58	67	70	72	73	75
48	66	64	75	71	74	71	79	75
72	65	70	76	75	74	71	67	68
Prattville 1982								
0	18	21	26	39	13	19	25	26
24	35	43	45	43	34	37	40	41
48	43	47	48	49	42	47	42	45
72	48	48	49	50	48	52	52	48
Headland 1981								
0	41	42	54	52	35	40	38	45
24	50	55	49	52	37	42	48	54
48	54	55	54	55	49	56	64	55
72	49	51	51	51	53	55	59	59
Headland 1982								
0	19	24	32	32	16	21	23	25
24	30	31	36	36	26	32	34	33
48	40	41	40	45	38	40	43	42
72	44	45	47	50	39	42	40	45

Values located within the shaded area are not statistically lower ($P \leq 0.10$) than the absolute highest yield.

permitting the use of less total N with a fall-spring combination than with spring N alone. This response occurred three times when soybeans were the previous crop and four times when sorghum was the previous crop.

Influence of Preceding Crop on Wheat and Fertilizer N Requirements

At optimum N rates and combinations, generally there was not much difference between yields of wheat following soybeans and yields following sorghum. Even when using the absolute highest yield in each experiment to determine which of the two previous crops resulted in the highest wheat yield, the only large difference occurred at Crossville in 1982. In this experiment, yield of wheat following soybeans was 40 percent higher than when sorghum was the previous crop.

To obtain relatively equal wheat yields, higher N rates were generally required when sorghum was the previous crop than when wheat followed soybeans. There were only three exceptions where the optimum N rate (fall plus spring combination that resulted in the lowest N rate required for optimum yield) for wheat following sorghum was less than or equal to the optimum N rate required for wheat following soybeans. These exceptions occurred at Prattville in 1981 and at Crossville and Headland in 1982. At Crossville, the N combination resulting in the lowest rate of total N required for optimum yield was 0-48 regardless of previous crop. As previously mentioned, this was the only experiment in which sorghum resulted in lower wheat yields than soybeans. At Headland, optimum N combinations were 0-72 and

TABLE 6. YIELDS OF THE PRECEDING CROPS AT EACH LOCATION AND YEAR

Previous crop location and year	Yield/acre Soybeans	Yield/acre Sorghum
	Bu.	*Bu.*
Plains		
1977	—[1]	—
1978	32	115
1979	41	90
1980	—	—
Calhoun		
1977	35	—
1978	61	80
1979	49	56
1980	—	—
Crossville		
1980	9	52
1981	34	58
Prattville		
1980	10	16
1981	25	38
Headland		
1980	15	85
1981	45	10

[1]Yield data not available.

12-48 when soybeans and sorghum, respectively, were the preceding crop; and at Prattville the optimum combinations were 24-48 and 12-24 for soybeans and sorghum, respectively. At both Prattville and Headland the preceding sorghum crop was a failure, table 6, and N applied to the sorghum (80 pounds per acre N) was evidently utilized to some effect by the subsequent wheat crop. In addition, the preceding soybean crops at Prattville (10 bushels per acre) and at Headland (15 bushels per acre) were poor, and N produced by these crops may have been low. The only other low previous crop yield occurred at Crossville in 1980. This low soybean yield (9 bushels per acre) did not result in higher N fertilizer needs when wheat followed soybeans as it did at Headland and Prattville when the preceding crop yields were low. The only locations in which more than 10 to 12 pounds per acre of fall N were needed to obtain the lowest total N for optimum yields of wheat following soybeans occurred when the preceding soybean yields were less than 15 bushels per acre.

Spring N, Total N, and Optimum N Combinations

There was a positive relationship between wheat yields and spring N rates. As previously discussed, the amount of spring N required for optimum yields was dependent on fall N and the previous crop. Spring N requirements also varied among years and locations. In table 7, the fall-spring combination resulting in the lowest total N rate required for optimum yield is listed along with the fall-spring combination which resulted in the absolute highest yield. Since the two yields are not significantly ($P \leq 0.10$) different, the treatment combination for each experiment that resulted in the lowest total fertilizer N requirement should be the optimum N combination for a specific location and year.

Neither the optimum N combination nor the total N rate required for optimum yield was related entirely to wheat yield levels. For example, for wheat following soybeans at Plains in 1981, the optimum combination was 10-40 (50 pounds per acre N), and in 1980 the optimum combination was 10-60 (70 pounds per acre N). The 50-pound-per-acre N rate in 1981 resulted in 63-bushel-per-acre wheat yields and the 70-pound rate in 1980 resulted in only 47 bushels. In other words, the amount of fertilizer N needed is not necessarily established by yield potentials.

Since N fertilizer requirements cannot be identified prior to harvesting wheat, and since optimum N combinations vary from

TABLE 7. FALL-SPRING COMBINATION RESULTING IN THE LOWEST TOTAL N RATE REQUIRED FOR OPTIMUM WHEAT YIELD, AND THE FALL-SPRING COMBINATION WHICH RESULTED IN THE ABSOLUTE HIGHEST YIELD FOR EACH YEAR AND LOCATION

Year and previous crop	Combi-nation[1]	Applied N/acre			Yield/ acre
		Fall	Spring	Total	
		Lb.	*Lb.*	*Lb.*	*Bu.*
Plains					
1978 Sorghum	1	0	60	60	31
	2	30	80	120	34
1979 Soybeans	1	0	20	20	47
	2	20	60	80	54
Sorghum	1	20	60	80	45
	2	20	80	100	52
1980 Soybeans	1	10	60	70	47
	2	30	80	110	52
Sorghum	1	10	80	90	53
	2	10	80	90	53
1981 Soybeans	1	10	40	50	63
	2	0	80	80	65
Sorghum	1	40	20	60	64
	2	40	80	120	68
Calhoun					
1978 Soybeans	1	0	80	80	58
	2	40	60	100	63
1980 Soybeans	1	10	20	30	40
	2	10	40	50	45
Sorghum	1	10	40	50	39
	2	30	60	90	45
1981 Soybeans	1	0	40	40	66
	2	0	80	80	71
Sorghum	1	10	80	90	64
	2	30	80	110	71
Crossville					
1981 Soybeans	1	24	24	48	45
	2	24	48	72	51
Sorghum	1	24	48	72	42
	2	36	72	108	53
1982 Soybeans	1	0	48	48	30
	2	36	48	84	38
Sorghum	1	0	48	48	23
	2	12	72	84	27
Prattville					
1981 Soybeans	1	24	48	72	75
	2	24	72	96	76
Sorghum	1	12	24	36	72
	2	24	48	72	79
1982 Soybeans	1	12	48	60	47
	2	36	72	108	50
Sorghum	1	0	72	72	48
	2	12	72	84	52

continued

TABLE 7. (CONTINUED) FALL-SPRING COMBINATION RESULTING IN THE LOWEST TOTAL N RATE REQUIRED FOR OPTIMUM WHEAT YIELD, AND THE FALL-SPRING COMBINATION WHICH RESULTED IN THE ABSOLUTE HIGHEST YIELD FOR EACH YEAR AND LOCATION

Year and previous crop	Combi-nation[1]	Applied N/acre			Yield/ acre
		Fall	Spring	Total	
		Lb.	*Lb.*	*Lb.*	*Bu.*
Headland					
1981 Soybeans	1	0	24	24	50
	2	12	24	36	55
Sorghum	1	12	48	60	56
	2	24	48	72	64
1982 Soybeans	1	0	72	72	44
	2	36	72	108	50
Sorghum	1	12	48	60	40
	2	36	72	108	45

[1]Combination 1 is the fall-spring combination that resulted in the lowest N rate required for optimum wheat yields. Combination 2 is the fall-spring combination that resulted in highest absolute wheat yield.

year to year and location to location within years, attempts were made to identify N combinations that would have resulted in optimum yields regardless of year or location. The fall-spring combinations resulting in the highest total N rates used would have resulted in maximum yield regardless of year or location, but these combinations would have resulted in excessive use of N fertilizer in each experiment. Several procedures including multiple regression were used to help identify optimum fall-spring N combinations. The most logical combinations were obtained from averaging the data in table 7 across locations and years for each fall-spring combination and each previous crop. The values were rounded to the nearest 5-pound level and listed in table 8.

When the average fall-spring N combinations, table 8, are compared back to the various combinations that resulted in optimum yields, tables 3-5, the following observations can be made:

1. When wheat followed soybeans:

The low N rate combination (10-45) resulted in suboptimum wheat yields in 5 of the 12 experiments (Plains in 1980, Calhoun in 1978, Crossville in 1981, Prattville in 1981, and Headland in 1982).

The high N rate combination (20-60) did not result in suboptimum wheat yields in any of the 12 experiments.

The average of the two combinations (15-53) resulted in suboptimum wheat yields in 3 of the 12 experiments (Calhoun in

TABLE 8. FALL-SPRING N COMBINATION (AVERAGED ACROSS YEARS AND LOCATIONS) RESULTING IN THE LOWEST TOTAL N REQUIRED FOR OPTIMUM YIELDS AND ABSOLUTE HIGHEST YIELDS

Previous crop	Combination[1]	Nitrogen/acre		
		Fall	Spring	Total
		Lb.	*Lb.*	*Lb.*
Soybeans	1	10	45	55
	2	20	60	80
	Mean	15	53	68
Sorghum	1	10	50	60
	2	25	70	95
	Mean	19	61	80

[1]Combination 1 is the fall-spring combination that resulted in the lowest total N required for optimum yields. Combination 2 is the fall-spring combination that resulted in absolute highest yields.

1978, Prattville in 1981, and Headland in 1982). In two of these three experiments, however, the preceding soybean yields were less than 15 bushels per acre.

2. When wheat followed grain sorghum:

The low N rate combination (15-20) resulted in suboptimum wheat yields in 6 of the 12 experiments (Plains in 1979, 1980, and 1981; Calhoun in 1981; Crossville in 1981; and Prattville in 1982).

The high N rate combination (25-70) did not result in suboptimum wheat yields in any of the 12 experiments.

The average of the two combinations (20-60) resulted in suboptimum wheat yields in 3 of the 12 experiments (Plains in 1980, Calhoun in 1981, and Prattville in 1982).

Soil and Plant N vs. Nitrogen Deficiencies

Just prior to spring N applications, soil (0 to 6-inch depth) and whole plant samples were collected for N analysis. The inorganic soil N (ammonium, nitrate, and nitrite) levels ranged from 6 to 20 pounds per acre. Differences found, however, were among locations and years and not between previous crops or among rates of fall N. No relationship was found between soil N levels and the amount of fertilizer needed by the wheat.

Nitrogen in the plant tissue samples, tables 9 and 10, generally increased with increasing rates of fall N. Nitrogen levels in the tissue were usually slightly higher when soybeans were the previous crop. At Prattville in 1981, however, the N levels were much

TABLE 9. NITROGEN IN WHEAT TISSUE JUST PRIOR TO SPRING N APPLICATIONS AT PLAINS AND CALHOUN, GEORGIA, AS AFFECTED BY PREVIOUS CROP AND FALL-APPLIED N

Fall N, lb./acre	Plant N, by previous crop and year							
	Soybeans				Sorghum			
	1978	1979	1980	1981	1978	1979	1980	1981
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Plains								
0	—	1.90	2.47	4.44	1.91	1.72	2.69	4.59
10	—	2.67	2.62	4.48	2.17	1.83	2.63	4.78
20	—	3.09	2.37	4.63	2.24	2.20	2.78	4.81
30	—	3.48	2.99	4.74	2.44	3.15	2.79	4.85
40	—	3.23	2.80	4.68	2.50	2.91	2.63	4.97
Calhoun								
0	2.91	2.92	2.67	4.80	—	2.74	2.74	4.40
10	3.88	3.00	2.66	4.81	—	2.85	2.37	4.46
20	3.96	3.27	2.66	5.06	—	3.10	2.63	4.71
30	4.41	3.38	2.90	4.97	—	3.38	2.77	4.71

TABLE 10. NITROGEN IN WHEAT TISSUE AT THE ALABAMA LOCATIONS IN 1981 AS AFFECTED BY THE PREVIOUS CROP AND FALL-APPLIED N

Fall N, lb./acre	Plant N, by location and previous crop					
	Crossville		Prattville		Headland	
	Soybeans	Sorghum	Soybeans	Sorghum	Soybeans	Sorghum
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
0	4.52	3.96	2.80	3.50	3.39	2.95
12	4.85	4.20	2.78	3.53	3.32	3.04
24	4.66	3.97	2.82	3.34	3.62	3.11
36	4.96	4.24	2.91	3.50	3.78	3.07

higher when sorghum was the previous crop. The greatest differences between tissue N levels occurred among years and locations.

Although there was a positive relationship between tissue N levels and yields, tissue N levels appear unsuited as an indicator for spring N requirements, primarily because of the variations that exist from year to year and location to location. For example, when wheat followed soybeans at Calhoun, the 1980 data suggest that wheat grain yields would not respond to spring applied N if tissue N level exceeded 2.66 percent, but in 1978 and 1981, critical N levels were 4.53 and 5.06 percent, respectively.

Rainfall vs. Yield

There is no doubt that rainfall and other climatic conditions are the primary factors that determine yield levels. With winter crops such as wheat, excessive and not deficient rain is probably

TABLE 11. RAINFALL DURING THE WHEAT GROWING SEASON AT EACH LOCATION

Month	Rainfall/month, by location and growing season													
	Calhoun				Plains				Crossville		Prattville		Headland	
	1978	1979	1980	1981	1978	1979	1980	1981	1981	1982	1981	1982	1981	1982
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
November	3.0	5.5	3.1	2.4	2.6	4.6	1.4	1.4	2.9	2.8	2.2	0.4	1.9	1.3
December	1.8	1.5	.7	6.9	2.0	2.6	.7	1.9	.9	6.6	1.8	7.1	1.2	8.2
January	7.3	6.5	5.2	.8	9.7	2.3	3.3	1.4	1.2	10.1	1.5	3.4	1.5	5.1
February	.7	5.2	1.9	6.2	2.6	2.8	2.0	8.9	7.4	6.9	7.7	9.6	9.6	9.4
March	4.8	7.9	14.8	4.5	4.8	2.1	9.8	5.1	5.5	2.9	5.2	2.9	6.2	3.3
April	2.9	11.2	5.8	3.5	3.6	1.9	4.3	2.1	4.4	9.3	5.9	8.9	.9	5.0
May	4.8	3.7	7.4	3.0	6.2	1.2	3.5	2.7	1.9	2.1	2.7	1.4	3.7	3.0

responsible for low wheat yields in most years. In the years that these experiments were conducted, it appears that 25 to 30 inches of rain during the wheat growing season (November-May) was the desirable quantity, table 11. The highest wheat yields at each location were obtained in 1981 when total rain during the growing season was 28, 24, 24, 28, and 25 inches for Calhoun, Plains, Crossville, Prattville, and Headland, respectively. Poorest yields were recorded in years with the most rain, at Calhoun in 1980, Plains in 1978, and all Alabama locations in 1982. In these years, total rain ranged from 31 to 41 inches. The exceptionally dry year at Plains in 1979 (18 inches of rain) may have restricted yield, but yields in 1979 averaged approximately 20 bushels per acre higher than in 1978 when rainfall exceeded 31 inches. It is difficult to single out a period in which excessive rain will cause the greatest yield reduction, but it appears that high rainfall in January, especially when coupled with high rainfall in December, may be the most devastating.

Since N efficiency is poorer in wet years than dry years, it would appear that fertilizer N requirements would be less in dry than wet years. Data from these experiments do not indicate that higher N rates will necessarily be required in the wetter years. At Plains, the wettest year was 1978 (32 inches), but N fertilizer requirement when sorghum was the previous crop was as high or higher in the other 3 years which were much drier (18 to 25 inches of rain). At Calhoun, the wettest year was 1980 (39 inches), and regardless of the previous crop, less N fertilizer was required in 1980 than in 1978 (25 inches) or 1981 (27 inches). Although disease data were not recorded in these experiments, it is well known that disease problems can be more severe in wet than dry years.

Plant disease may have limited yields in some of the wet years, thus decreasing the N fertilizer requirement in situations where N efficiency should theoretically be poor and fertilizer needs should theoretically be high. In other words, it appears that N fertilizer requirements are higher in dry than wet years, which indicates that climatic effects on yield potentials are more important than climatic effects on N efficiency.

SUMMARY AND CONCLUSIONS

Wheat following sorghum will yield as high as wheat following soybeans, but N fertilizer requirements (both fall and spring) will be higher (15 to 30 pounds per acre) when wheat follows sorghum.

Soil N levels cannot be used to determine the amount of fertilizer N needed, regardless of the previous crop.

Tissue analysis may identify a N deficiency, but N levels in the plant tissue cannot be used to predict N fertilizer requirements.

High rainfall years do not increase N fertilizer requirements. Yield potentials will, however, be low in wet years, especially when excessive rain occurs in January and February. The adverse effect of wet weather on yield potential exceeds and masks the adverse effects of wet weather on N efficiency. The data actually indicate that N fertilizers rates can be reduced in wet years.

Fall-applied N is critical when wheat follows sorghum. Unless soybean yields are low (less than 20 bushels per acre) optimum wheat yields can be obtained without any fall N. However, even in years when fall N is not required for optimum wheat yield, applying fall N will reduce spring N requirements, thus permitting the use of less total N with a fall-spring combination than with spring N alone.

Although fall-applied N may reduce the amount of spring N needed, it cannot replace spring N.

Many conclusions about optimum N combinations can be drawn from the data presented in this report, including the following guide for safe N application for wheat:

1. Wheat following soybeans—15 pounds per acre at planting followed by 50 pounds just prior to jointing, which normally occurs in February or early March, unless soybean yields were low (less than 20 bushels per acre), in which case N rates should be increased to 20 pounds at planting and 60 pounds prior to jointing.

2. Wheat following sorghum—25 pounds per acre in the fall followed by 70 pounds just prior to jointing.

APPENDIX

GRAIN YIELD STATISTICAL PROBABILITY LEVELS FOR FALL N, SPRING N, AND FALL-SPRING INTERACTIONS

Year and location	Soybeans			Grain sorghum		
	Fall N	Spring N	Int.	Fall N	Spring N	Int.
1978						
Calhoun	.0001	.0001	.0005	—	—	—
Plains	—	—	—	.008	.0001	.18
1979						
Plains	.08	.0001	.24	.0001	.0001	.68
1980						
Calhoun	.20	.006	.006	.001	.0001	.20
Plains	.0001	.0001	.50	.0001	.0001	.03
1981						
Calhoun	.38	.0001	.29	.001	.0001	.20
Plains	.02	.0001	.26	.0001	.001	.09
Crossville	.03	.0001	.77	.0001	.0001	.93
Prattville	.0001	.0001	.02	.004	.0001	.0001
Headland	.16	.01	.18	.0008	.0001	.36
1982						
Crossville	.66	.003	.73	.19	.0001	.08
Prattville	.0001	.0001	.05	.005	.0001	.12
Headland	.0008	.0001	.53	.002	.0001	.84

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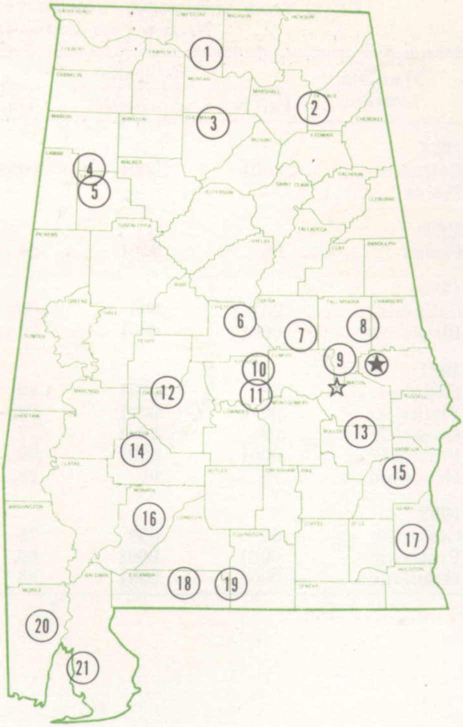

Research Unit Identification

⊛ Main Agricultural Experiment Station, Auburn.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Chilton Area Horticulture Substation, Clanton.
7. Forestry Unit, Coosa County.
8. Piedmont Substation, Camp Hill.
9. Plant Breeding Unit, Tallassee.
10. Forestry Unit, Autauga County.
11. Prattville Experiment Field, Prattville.
12. Black Belt Substation, Marion Junction.
13. The Turnipseed-Ikenberry Place, Union Springs.
14. Lower Coastal Plain Substation, Camden.
15. Forestry Unit, Barbour County.
16. Monroeville Experiment Field, Monroeville.
17. Wiregrass Substation, Headland.
18. Brewton Experiment Field, Brewton.
19. Solon Dixon Forestry Education Center, Covington and Escambia counties.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.