Spring Nitrogen Application Timings as They Influence Yield and Protein in Wheat

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Abstract

High yielding wheat varieties often have lower protein content unless the timing of nitrogen applications is carefully managed. Nitrogen (N) was topdressed on wheat (Triticum aestivum L. cv "Anza") at up to four rates 34, 67, 101 and 134 kg ha^{-1} on six dates at 15 day intervals beginning Feb 1 to April 15. A combination treatment of 101 kg ha^{-1} on Feb 1 plus 34 kg ha^{-1} on April 15 along with a control made 16 treatments. Significantly higher yields and protein resulted with higher N rates applied earlier in the season during high rainfall years. The 34 kg ha^{-1} rate had progressively higher protein with later applications and the combination treatment maximized yield and protein.

Objective

To evaluate the effect of timing and rate of topdressed nitrogen on the yield, yellow berry and protein content of Anza wheat.

Methods

The basic field research plan was to select a field where a grower had established a satisfactory stand of Anza wheat and supplement the nitrogen applied at planting time with topdressed nitrogen at 15 day intervals beginning approximately February 1st and continuing through April 15th. Table 1 gives the site characteristics and the experimental conditions during the four years. Ammonium nitrate was the form of nitrogen fertilizer used. The rate of nitrogen applied varied with the higher rates being gradually dropped as the stage of plant growth progressed as Table 2 indicates. Each of the 15 treatments was replicated 4 times. A sixteenth treatment, 101 kg ha^{-1} at tillering stage plus 34 kg ha^{-1} at head emergence or soon after was added the last two years as is indicated in Table 4 and 5.

Table 1. Site characteristics and experimental conditions during the four years.

Soil Type	Previous Crop	Preplant Nitrogen (kg ha^{-1})	Rainfall (cm)	Irrigation (cm)	Drainage
Tehama silt loam	Corn	83	21.6	38.1	Good
Plaza silt loam	Rice (3)	119	65.3	7.6	Fair
Marvin silty clay loam	Rice (4)	146	38.1	15.2	Good
Wyo/Plaza silt loam	Rice (4)	157	68.6	7.6	Fair

Results and Discussion

The 1976-77 trial conducted during a very dry winter resulted in the preplant application of 83 kg ha^{-1} of nitrogen being sufficient to produce over 8000 kg ha^{-1} of Anza wheat where corn was the previous crop (Table 2). Even though five irrigations representing a total of approximately 38 cms of water were applied, no significant yield increase was observed from any topdressing treatment. This seemingly indicated little nitrate leaching or denitrification and adequate nitrogen mineralization to achieve the high yields and moderate protein levels. While only limited and selected treatments were analyzed for protein and evaluated for yellow berry, there appeared to be no difference between treatments.

Table 2. Grain yield, dark, hard vitreous kernels and protein of Anza wheat as influenced by rate and timing of topdressed nitrogen in 1976-77.

Trt. No.	Nitrogen Application Date	Rate (kg ha^{-1})	Yield (kg ha^{-1})
1.	1/31/77	34	8315
2.	1/31/77	67	8297
3.	1/31/77	101	7948
4.	1/31/77	134	8428
5.	2/15/77	34	7870
6.	2/15/77	67	8352
7.	2/15/77	101	8497
8.	3/2/77	34	8169
9.	3/2/77	67	8304
10.	3/2/77	101	8588
11.	3/18/77	34	8225
12.	3/18/77	67	8341
13.	4/1/77	34	8532
14.	4/13/77	34	8305
15.	Control	0	8420

The 1977-78 grain growing season represented a wet, warm winter. The topdressing trial established following rice received 119 kg ha^{-1} preplant nitrogen resulted in dramatic yield increases when topdressed in the tillering to jointing stages of growth (Table3). Yields, as well as protein and dark, hard, vitreous kernels of the Anza wheat for the 15 nitrogen rate and timing treatments are given in Table 3. The nitrogen applications made on the earliest dates February 1st (approximately tillering stage) and February 15th (beginning jointing stage), gave similar yield response with increasing

Figure 1. Wheat yield response to rate and timing of topdressed nitrogen application in 1977-78.

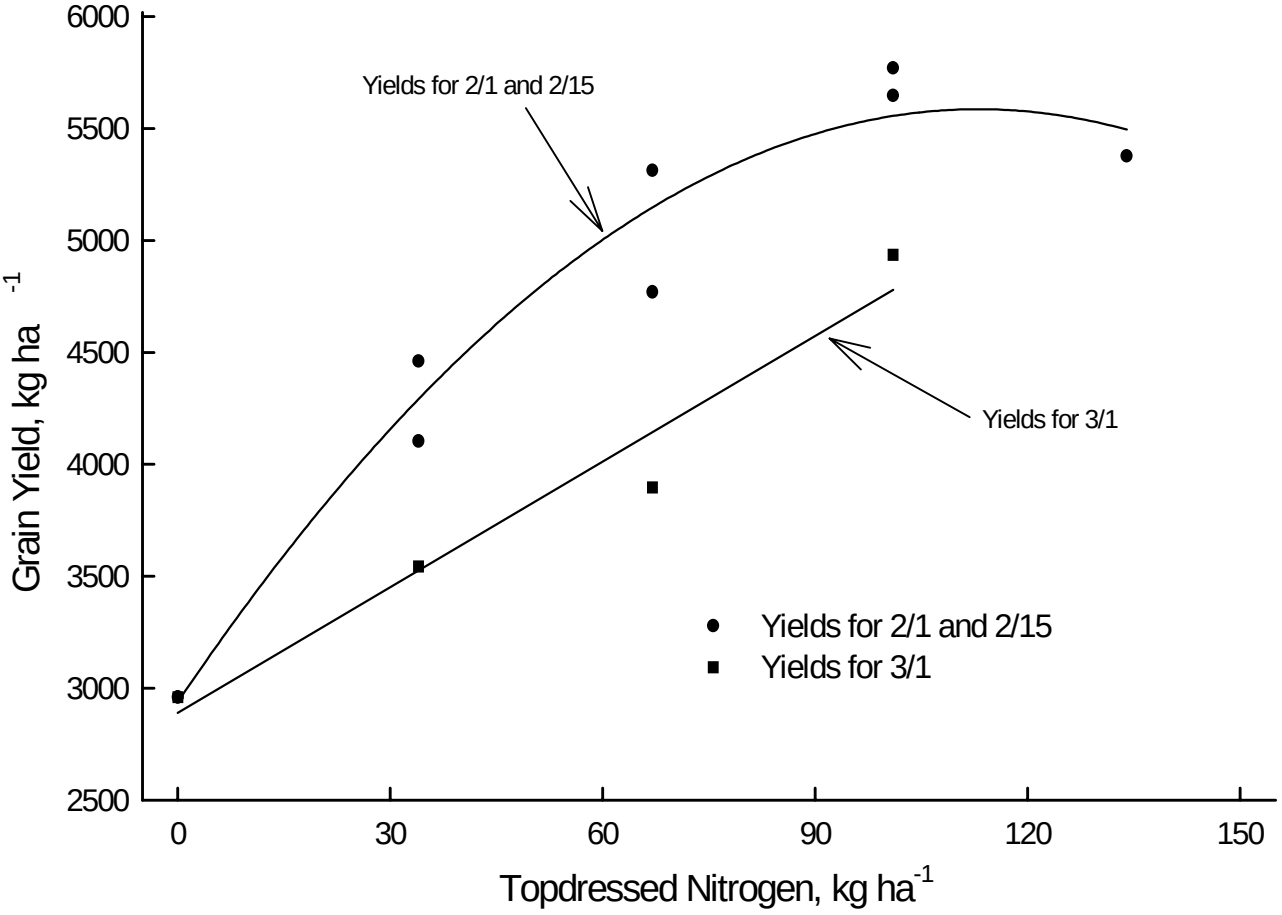

Figure 2. Wheat yield and protein response to 34 kg ha-1 nitrogen applied at different times in 1978.

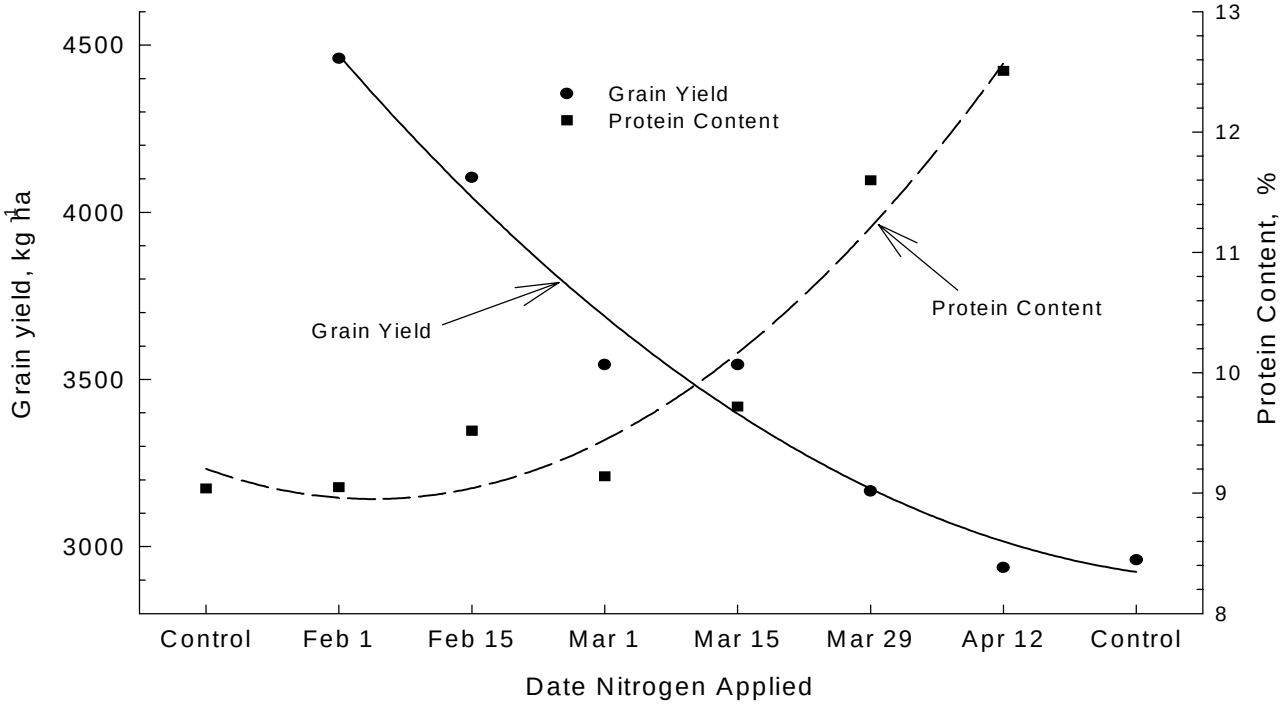

Table 3. Grain yield, dark, hard vitreous kernels and protein of Anza wheat as influenced by rate and timing of topdressed nitrogen in 1977-78.

Trt. No.	Nitrogen Application Date	Rate (kg ha^{-1})	Yield (kg ha^{-1})	DHV* Kernels (%)	Protein (%)
1.	2/1/78	34	4460	45	9.05
2.	2/1/78	67	4770	48	
3.	2/1/78	101	5770	63	
4.	2/1/78	134	5377	47	
5.	2/15/78	34	4104	54	9.52
6.	2/15/78	67	5313	47	
7.	2/15/78	101	5647	48	
8.	3/1/78	34	3544	43	9.14
9.	3/1/78	67	3897	53	
10.	3/1/78	101	4937	39	
11.	3/15/78	34	3544	60	9.72
12.	3/15/78	67	4084	71	
13.	3/29/78	34	3166	79	11.60
14.	4/12/78	34	2937	85	12.51
15.	Control	0	2960	46	9.04
	$LSD_{0.05}$		1179	15	0.83

rates of nitrogen. The yield increase was smaller at all levels of topdressed nitrogen with applications on or after March 1st (Figure1). Figure 2 illustrates the decline in grain yield response to 34 kg ha^{-1} nitrogen applied at different times throughout the growing season. Indicated as well is the increase in percent dark, hard, vitreous kernels (DHV) as the nitrogen is applied at a later growth stage, particularly on March 29th (heading) and April 12th (post-heading). Note that increases in protein content parallel the increase in DHV kernels with the later application of nitrogen (Table 3). Even though the protein content was not determined for the higher nitrogen rates, the data presented would indicate that approximately 101 kg N ha^{-1} between tillering and initiation of jointing would result in maximum yield and that approximately 34 kg N ha^{-1} applied after heading would result in the highest protein and percent dark, hard, vitreous kernels. These experimental results would suggest considerable leaching and denitrification of the preplant nitrogen occurred during the high rainfall winter (65.3 cm) and the low mineralization rate of soil nitrogen do to the saturated soil conditions.

In the 1978-79 season when Anza wheat followed rice during a more moderate rainfall year (with a considerable portion of the rainfall coming after January 1st), the preplant 146 kg N ha^{-1} was sufficient to produce 6951 kg ha^{-1} of wheat. Topdressing

Table 4. Grain yield, dark, hard vitreous kernels and protein of Anza wheat as influenced by rate and timing of topdressed nitrogen in 1978-79.

Trt. No.	Nitrogen Application Date	Rate (kg ha^{-1})	Yield (kg ha^{-1})	DHV* Kernels (%)	Protein (%)
1.	2/5/79	34	7486	14	10.62
2.	2/5/79	67	7293	25	11.90
3.	2/5/79	101	7288	42	12.87
4.	2/5/79	134	7271	45	12.75
5.	2/16/79	34	7372	12	10.60
6.	2/16/79	67	7323	19	11.50
7.	2/16/79	101	6842	38	12.82
8.	3/2/79	34	7543	13	10.57
9.	3/2/79	67	7259	22	11.80
10.	3/2/79	101	6786	51	12.82
11.	3/14/79	34	7129	11	10.77
12.	3/14/79	67	7638	23	11.47
13.	3/30/79	34	7697	11	10.90
14.	4/16/79	34	7690	24	11.57
15.	Control	0	6951	8	10.10
16.	2/5/79 4/16/79	101 + 34	7262	53	12.82
	$LSD_{0.05}$		NS	11	0.58

treatments did not increase yields. However, some topdressing treatments did result in a higher percentage of dark, hard, vitreous kernels and increase in protein (Table 4).

The 1979-80 trial was established following rice and experienced high rainfall (68.6 cms). Grain yield, dark, hard vitreous kernels and protein data are given in Table 5. Two periods during the winter resulted in especially high rainfall in relatively short periods of time. While yield increases from topdressing were not as dramatic as the wet, warm winter of 1977-78, 101 or 134 kg N ha^{-1} topdressed at tillering to early jointing and 67 or 101 kg N ha^{-1} at various stages of jointing (2/16 and 3/3) resulted in significant increases in yield. In most instances 67 kg N ha^{-1} or more significantly increased protein. While most N topdressing treatments increased the percent of dark, hard, vitreous kernels, only two treatments 34 kg N ha^{-1} (4/14/80) and 101 kg N ha^{-1} (2/4/80) plus 34 kg N ha^{-1} (4/14/80) increased the DHV kernel level to above 40%.

Table 5. Grain yield, dark, hard vitreous kernels and protein of Anza wheat as influenced by rate and timing of topdressed nitrogen in 1979-80.

Trt. No.	Nitrogen Application Date	Rate (kg ha^{-1})	Yield (kg ha^{-1})	DHV* Kernels (%)	Protein (%)
1.	2/4/80	34	5901	17	10.68
2.	2/4/80	67	5964	23	10.90
3.	2/4/80	101	6574	19	11.93
4.	2/4/80	134	6476	37	12.18
5.	2/16/80	34	5619	15	10.00
6.	2/16/80	67	6431	15	10.43
7.	2/16/80	101	6443	21	10.83
8.	3/3/80	34	6108	11	10.43
9.	3/3/80	67	6296	25	11.08
10.	3/3/80	101	6576	33	12.35
11.	3/17/80	34	6039	14	10.50
12.	3/17/80	67	6833	30	12.15
13.	3/31/80	34	5793	27	10.75
14.	4/14/80	34	5414	42	11.38
15.	Control	0	5612	15	9.95
16.	2/4/80 4/14/80	101 + 34	6805	56	13.50
	$LSD_{0.05}$		694	9	0.67

Summary

1. During the very dry year of 1976-77 there was no increase in yield from N topdressing when Anza wheat followed corn where 83 kg N ha^{-1} was applied preplant on an adequately drained soil.

2. The especially wet, warm 1977-78 crop year resulted in the topdressed nitrogen of Anza wheat during the tillering and jointing stages to have significantly increased yields over the preplant application of 119 kg N ha^{-1} (94 kg N ha^{-1} as aqua-ammonia + 22 kg N ha^{-1} from 18-46-0 with the seed). The late application of 34 kg N ha^{-1} increased the percentage of dark, hard, vitreous kernels and protein. The wheat followed rice under conditions of fair drainage.

3. During 1978-79, a year of moderate rainfall, N topdressing of Anza wheat did not result in yield increases beyond that obtained from 146 kg ha^{-1} preplant nitrogen. However, the percentage of dark, hard, vitreous kernels and percent protein were

significantly increased with higher N topdressing rates applied early or with as low as 34 kg N ha^{-1} applied at the boot to heading stage. The Anza wheat followed rice on reasonably well-drained soil.

4. Nitrogen topdressing of Anza wheat significantly increased grain yield in the high rainfall year of 1979-80. This occurred when generally more than 67 kg ha^{-1} of nitrogen was applied from 2/4/80 to 3/17/80 (with the exception of 67 kg N ha^{-1} on 2/4 and 3/3). While various N topdressing treatments increased the percent dark, hard, vitreous kernels, only the very late 4/12/80 – 34 kg N ha^{-1} and the treatment receiving two topdressings (101 kg N ha^{-1} on 2/4/80 plus 34 kg N ha^{-1} on 4/12/80) resulted in DHV kernel percentages above 40%. Protein was increased as the rate of N applied increased on any specific application date. In general, the protein increased as the same rate of N was applied at a later date. As in the two previous years, the latest application of 34 (after heading in 1979-80) significantly increased protein. It is believed the low DHV kernel and protein levels on 2/16/80 may have been influenced by 11.5 cms of rainfall occurring between 2/16/80 and 2/21/80.

5. During the two high rainfall years, 1977-78 and 1979-80, significant and economical yield responses were obtained with some treatments. The low rainfall years, 1976-77 and 1978-79, resulted in the preplant applied nitrogen being sufficient to give adequate yield levels. One might conclude that if topdressing of N is required, 34 kg ha^{-1} may not be adequate to achieve maximum yield responses during wet winters in the Sacramento Valley on some soils.

6. Although an increase in the percentage of dark, hard, vitreous kernels and protein were obtained with certain treatments during the last three years of the study; the economics of applying topdressed N for these purposes must be compared on a cost-return basis. The return for any premium for quality or protein must exceed the fertilizer and application costs.

7. Until mid 1978 the percent dark, hard, vitreous (DHV) kernels designation was included in the subclasses of the U. S. Grain Standards for Hard Red Winter Wheat. Since then, the dark, hard, vitreous criterion has been dropped from the standards.