BORON FERTILIZATION OF WHEAT

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Justification and Objectives:

This study was initiated in the fall of 2004 in order to help verify the effect of boron applications to wheat yields and milling properties of the grain. Preliminary results from a study of similar design in 2002 did not increase yields but did result in increased milling quantity for some boron application treatments. The results for the milling measurements were not replicated so the results were not scientifically reliable. A similar study was completed and reported in 2003 and yield and milling quality was unaffected by the treatments in the study. This study should help with the verification of the previous trials concerning the milling quality, as well as yields.

Method:

The soil is a Pembroke silt loam and the field is located on the UK Research and Education Center at Princeton, KY. This field has been marginally low in soil test boron in the past. The research was accomplished on small plots (7' x 15'). Six different varieties of wheat were no-till planted at 35 seeds/sq foot on Oct. 22, 2004. Warrior insecticide was applied in November and again in March. Tilt fungicide was applied at heading and N was applied at the rate of 40 lb/ac at Feekes 3 and 80 lb/ac at Feekes 5.

A soil sample was taken prior to planting from the total plot area. The results were: pH 6.2, P 76 lb/ac., K 283 lb/ac. with Mehlich 3 extractant. No additional fertilizer was required. Each replication was soil sampled for boron analysis on April 14 and the average hot water extractable B was 0.6 lb/ac. Harmony Extra herbicide and Warrior insecticide were applied on March 15. Granular boron (14.3% B) was applied on March 25, by hand, mixed with 350 ml of sand. Boron sprayed as Solubor (20.5% B) at head emergence (prior to flowering) on April 27 and May 11 for the treatment requiring a second application. Flag leaves were sampled at heading. The plots were harvested on June 20 with a Hege plot combine. Samples were measured and subsamples (500 gm) were sent to the USDA, ARS Soft Wheat Quality Laboratory at Wooster, Ohio for milling property measurements.

Trial Design

1) **Varieties** — **Overall Milling Quality History***

Varieties	Overall Milling Quality History*
Foster	25
Pioneer 25R23	42
Pioneer 25R47	66
McCormick	257
Coker 9663	540
Roane	675

*The higher the number, the lower the wheat quality

2) **Boron Treatments**
   a. Control (no B added)
   b. 0.25 lb/ac. B foliar applied at initial heading.
   c. 0.25 lb/ac. B soil applied at Feekes 5 to 6 growth stage.
   d. 0.50 lb/ac. B soil applied at Feekes 5 to 6 growth stage.
   e. 2 lb/ac. B soil applied at Feekes 5 to 6 growth stage.
   f. 1 lb/ac. B foliar applied with split application. One half at initial heading and one half 2 weeks after first application

Results:

Soil Boron

Each replication was soil sampled to a 6 inch depth on April 14 and the hot water extractable B analyses were made at the University of Kentucky Soil Testing Laboratory. The combined soil boron value was 0.6 lb/ac. This is quite low and in a range where you might expect a response to boron. Similar values in 2003 and 2004 did not result in yield increases and none was found again this year.

Flag Leaf Boron Concentrations

Flag leaf concentrations at flower initiation indicate that B concentrations were at or slightly below the minimum sufficient level of 6 ppm in the control treatment in the varieties tested. The soil treatments were less effective in raising the flag leaf concentrations than the foliar treatments at similar rates. The 0.25 lb/ac B soil application numerically raised the leaf concentrations above the control but it was not statistically higher. The 0.5 lb/ac B soil treatment raised the leaf concentrations into the sufficient level on all varieties. The 2 lb/ac. B soil treatment raised the leaf concentrations to high levels with all varieties.

The foliar treatments were very effective in raising the B leaf concentrations. The 0.25 lb/ac treatment increased to B leaf concentrations well into the sufficiency range. The 0.5 lb/ac foliar application (1/2 of the 1.0 lb/ac B foliar treatment) increased the flag leaf concentrations similar to the 2 lbs/ac. B soil treatment. In this study, it appears that approximately 4 times more soil applied B is required to raise the flag leaf B to similar concentrations.

We know from this analysis that the applied B was moving into the plant and increasing the B plant concentrations to high levels at the higher treatment rates.

Table 1. Effect of Boron Application on Flag Leaf B Content

Treatment	***B Concentration (Avg. 4 Replications)******					
	Varieties					
	Roane	**McCormick**	**Foster**	**Coker 9663**	**Pioneer 25R47**	**Pioneer 25R23**
	PPM					
1) Control (OB)	4.0 d *	6.5 d	5.3 e	5.5 c	5.3 d	5.8 d
2) 0.25 lb./A B Foliar	10.3 c	16.5 b	14.3 c	17.0 b	13.3 c	10.0 c
3) 0.25 lb./A B Soil	5.0 d	8.3 d	7.3 de	7.0 c	5.8 d	5.8 d
4) 0.5 lb./A B Soil	7.8 cd	11.0 c	9.0 d	8.8 c	6.0 d	7.8 cd
5) 2 lb./A B soil	26.0 a	22.8 a	21.5 a	22.3 a	20.3 b	24.3 a
6) 1 lb. /A B Foliar (split)**	17.5 b	22.8 a	17.5 b	24.5 a	27.3 a	17.3 b
	*	*	*	*	*	*

* - Different letters in the same column indicate statistical differences at 0.1 level.
** - Only ½ of this treatment had been applied at sampling time.
*** - Sufficiency Range 6 to 20 ppm B.

Grain Boron Concentrations

The application of B to the soil and to the foliage did not affect the level of B in the grain except for one variety. The 2 lbs/ac of B soil treatment significantly increased the B in the grain in the McCormick variety. All other treatments in the variety had no measurable effect and the 2 lbs/ac of B soil treatment was not effective in increasing the B grain concentration in any of the other five varieties. The increased B concentrations in the grain in this one treatment was not due to exceptionally higher flag leaf concentrations in this variety or due to lower or higher yields for this treatment.

Even though the plants had high levels of B with the higher soil and foliar B treatments, the B in the grain was not affected by this, except in one treatment in one variety. The genetically plant controlled internal regulatory factors appears to exclude the higher B plant levels from entering the seed and expressing itself.

Table 2. Effect of Boron Application on Grain B Content						
	B Concentration (Avg. 4 Replications)					
Treatment	Varieties					
	Roane	McCormick	Foster	Coker 9663	Pioneer 25R47	Pioneer 25R23
	---------- PPM ----------					
1) Control (OB)	0.75	1.50 b	1.25	1.0	0.25	1.0
2) 0.25 lb./A B Foliar	0.25	2.0 b	1.25	0.5	0.75	0.5
3) 0.25 lb./A B Soil	0.50	1.50 b	1.0	1.0	0.75	0.5
4) 0.5 lb./A B Soil	1.0	1.50 b	1.25	0.75	0.25	0.75
5) 2 lb./A B soil	1.25	2.75 a	1.25	0.50	0.75	0.75
6) 1 lb./A B Foliar	0.50	1.75 b	1.25	0.75	0.25	1.0
	N.S.	*	N.S.	N.S.	N.S.	N.S.
* - Different letters in the same column indicate statistical differences at 0.1 level.						

Wheat Yields

The yields for each treatment and variety are found in table 3. The yields of all varieties were very high with some varieties being exceptional. This should have allowed a yield expression if B was limiting since no other factors appeared to limit yield.

There was little indication that the B was a limiting yield factor in all but one of the varieties and treatments. There was a statistical yield response to the 2 lbs/ac. soil B treatment in Pioneer 25R23. No other B treatment yields were significantly higher and the two other soil B treatments in this same variety were significantly lower. This indicates that overall B had little effect on yield.

Even with only 0.6 lb/ac of hot water extractable B found in the soil and less than 6 ppm B in the flag leaf in 5 of the 6 varieties in the control treatment, the yields appeared to be unaffected by B applications. The Roane variety had 4 ppm of B in the flag leaf in the control treatment and still did not respond to the B applications.

This and previous years data indicate that wheat is very efficient in extracting B from the soil and using it in the plant. The wheat plant is able to yield at very high levels with marginal B in the soil and marginal B in the plant.

Table 3. Effect of Boron Application on Grain Yields						
	Yields (Avg. 4 Replications)					
Treatment	Varieties					
	Roane	McCormick	Foster	Coker 9663	Pioneer 25R47	Pioneer 25R23
	---------- bu/ac ----------					
1) Control (OB)	103.1	119.4	125.0	131.4	144.9	128.1 bc
2) 0.25 lb./A B Foliar	100.8	139.5	119.8	133.2	136.7	131.0 ab
3) 0.25 lb./A B Soil	109.2	133.4	124.3	133.8	142.1	124.6 c
4) 0.5 lb./A B Soil	107.5	140.8	124.2	137.6	141.7	123.5 c
5) 2 lb./A B soil	106.4	137.4	125.3	136.5	140.7	135.8 a
6) 1 lb./A B Foliar	106.8	131.5	124.1	134.8	143.3	127.1 bc
	N.S.	N.S.	N.S.	N.S.	N.S.	*
* - Different letters in the same column indicate statistical differences at 0.1 level.						

Test Weights

The test weights are shown in table 4. The test weights are very high and were not affected by B additions to the soil or to the plant. Neither the McCormick 2 lbs/ac B soil treatment, which had significantly higher B in the grain, or the Pioneer 25R23, which had significantly higher yield, with the 2 lb/ac B soil treatment showed different test weights that the other treatments within those varieties.

Test weights appeared to be unaffected by the B treatments.

Table 4. Effect of Boron Application on Test Weight

	Test Weight (Avg. 4 Replications)					
Treatment	***Varieties***					
	Roane	**McCormick**	**Foster**	**Coker 9663**	**Pioneer 25R47**	**Pioneer 25R23**
	---------- PPM ----------					
1) Control (OB)	64.2	64.4	62.5	63.2	60.4	61.0
2) 0.25 lb./A B Foliar	64.2	64.5	62.2	63.5	60.4	61.1
3) 0.25 lb./A B Soil	64.3	64.4	62.5	63.2	60.6	61.5
4) 0.5 lb./A B Soil	64.4	64.5	62.4	63.2	60.5	61.5
5) 2 lb./A B soil	64.1	64.5	62.5	63.3	60.4	61.2
6) 1 lb./A B Foliar	63.9	64.5	62.4	63.1	60.5	60.8
	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Milling Quality

The milling quality score as tested by the USDA-ARS Soft Wheat Quality Laboratory at Wooster, Ohio is shown in table 5. There are large differences in milling quality among varieties but no differences within varieties due to treatment. Neither the McCormick 2 lbs/ac soil treatment, which had significantly higher B in the grain, or the Pioneer 25R23 2 lb/ac soil treatment, which had a significantly higher yield, showed different milling quality within their respective varieties.

Milling quality appears to be unaffected by B, if sufficient quantities of B are in the plant for maximum yields.

Table 5. Effect of Boron Application on Milling Quality Score

	Milling Quality Score (Avg. 4 Replications)					
Treatment	***Varieties***					
	Roane	**McCormick**	**Foster**	**Coker 9663**	**Pioneer 25R47**	**Pioneer 25R23**
	---------- PPM ----------					
1) Control (OB)	43.9 E	67.6 C	84.3 A	56.6 D	79.1 B	81.7 A
2) 0.25 lb./A B Foliar	43.3 E	67.6 C	84.0 A	55.9 D	79.1 B	83.5 A
3) 0.25 lb./A B Soil	43.9 E	68.5 C	85.8 A	56.2 D	78.8 B	82.3 A
4) 0.5 lb./A B Soil	43.9 E	67.1 C	85.0 A	55.7 D	79.9 B	81.0 A
5) 2 lb./A B soil	43.3 E	68.5 C	85.4 A	56.3 D	79.5 B	81.4 A
6) 1 lb./A B Foliar *	44.1 E	68.3 C	85.0 A	55.8 D	78.8 B	83.1 A
	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Baking Quality

The baking quality scores as tested by the Soft Wheat Quality Laboratory are found in table 6. There are large differences among varieties but not within varieties.

Baking quality appears to be unaffected by B, if sufficient quantities of B are in the plant for maximum yields.

Table 6. Effect of Boron Application on Baking Quality

Treatment	***Baking Quality Score (Avg. 4 Replications)***					
	Varieties					
	Roane	**McCormick**	**Foster**	**Coker 9663**	**Pioneer 25R47**	**Pioneer 25R23**
	---------- PPM ----------					
1) Control (OB)	39.2 F	48.2 E	73.3 B	46.1 E	86.7 A	66.7 C
2) 0.25 lb./A B Foliar	37.8 F	46.5 E	72.7 B	48.4 E	88.8 A	66.0 C
3) 0.25 lb./A B Soil	39.7 F	48.0 E	74.5 B	47.6 E	89.1 a	66.2 C
4) 0.5 lb./A B Soil	38.8 F	48.0 E	72.1 b	46.7 E	87.1 A	66.4 C
5) 2 lb./A B soil	38.6 F	48.2 E	76.2 B	45.3 E	88.2 A	66.2 C
6) 1 lb./A B Foliar	37.9 F	48.9 E	71.8 B	49.7 E	87.0 A	65.6 C
	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Conclusions:

In 2002, unreplicated milling quality tests on one wheat variety indicated that milling quality may be improved by the addition of boron. A similar study was completed in 2003 and milling quality was not effected by boron fertilization on a different and single wheat variety. This 2004-2005 study used six different varieties with wide differences in milling quality. Boron fertilization, to the soil or the foliage, did not affect milling quality or quantity with any of the B treatments on any of the varieties. It is concluded from this study that the 2002 data was either an anomaly or the B effect occurs so rarely it may be impossible to predict.

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