

# Does Placement of Phosphorus and Potassium Fertilizer Matter?

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UNIVERSITY OF MINNESOTA  
Driven to Discover<sup>SM</sup>

# Why deep band P and K fertilizer?

- When P and K soil test levels are low
- With strip-till and no-till (4R practice)
  - Saves time & money in strip-till, reduce runoff of P
- Minimize stratification of immobile nutrients from broadcast application in reduced tillage.
  - More important with K than P (plant K uptake)
- Fixation of P and “tie up” of K in soil
  - P fixation (high or very low pH soils), K tie-up between clay layers (illite, vermiculite and smectite clays)
- Greater yields and FUE
  - Rehm and Lamb (2004) banded K increased corn yield in ridge-till, interaction with hybrid
  - Mallarino et al. (1999, 2004) occasional corn yield response to banded K, no effect of placement for P
- Economics: use less fertilizer, increase ROI



# Why deep band P and K fertilizer?

- Current U of MN fertilizer guidelines suggest a rate reduction when using band vs broadcast application for corn.
  - Rates based on 201-225 bu/ac expected yield.
- **A rate adjustment is NOT recommended for soybean.**

Soil test /	Soil test level			
Placement	Very low	Low	Medium	High
<b>Bray P1:</b>	<b>0–5 ppm</b>	<b>6–10</b>	<b>11–15</b>	<b>16-20</b>
<b>Olsen P:</b>	<b>0–3 ppm</b>	<b>4–7</b>	<b>8–11</b>	<b>12-15</b>
	----- lb P <sub>2</sub> O <sub>5</sub> per acre -----			
Band	65	45	30	10-15
Broadcast	130	90	55	20
<b>Soil test K:</b>	<b>0–50 ppm</b>	<b>51–100</b>	<b>101–150</b>	<b>151-200</b>
	----- lb K <sub>2</sub> O per acre -----			
Band	105	80	55	10-15
Broadcast	210	155	90	30



# Rate reduction guidelines for South Dakota

- SDSU Extension, Fertilizer Recommendation Guide, Clark, review 2019. Gerwing and Gelderman, 2005.
  - “Banding P and K near the seed **as a starter** frequently results in more efficient use of these fertilizers. Therefore, when starter phosphorus and potassium are used, rates can sometimes be reduced by one-third or more and still reach maximum yield. However, when rates are reduced, application may be below maintenance levels, resulting in a soil test level decline with time, especially with phosphorus.”

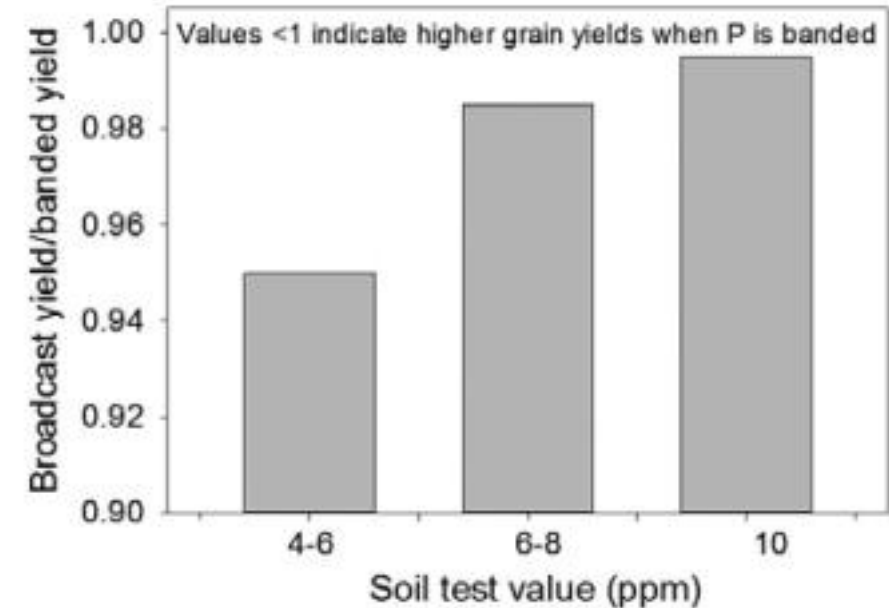


Figure 26.4 Relative no-till corn grain yield of broadcast and banded P comparisons at 9 locations in SD from 1998 to 1999.

SDSU Best Management Practices Ch. 26  
Starter, Banding, and Broadcasting  
Phosphorus Fertilizer for Profitable  
Corn Production. Bly et al., 2015.

# Rate reduction guidelines for North Dakota

- NDSU Extension, North Dakota Fertilizer Recommendation Tables and Equations, Franzen, 2018.
  - “The rate of phosphorus (P) and potassium (K) recommended in these tables is the amount to be applied as a broadcast application. Because banded fertilizer generally is used more efficiently in the year of application, the amount of  $P_2O_5$  and  $K_2O$  in the tables can be reduced by one-third when banding and the result will be similar to the yield with the full broadcast fertilizer rate.”
  - **“Broadcast recommendations of P and K for low- and very low-testing soils may include buildup P and K rates. When rates are reduced, soil test levels are not increased through time.”**

# Minnesota research site characteristics

- Locations, soil types and parent materials
  - **Waseca:** Nicollet-Webster clay loam, glacial till (poorly drained, tilled), 5-6% SOM, water pH 6.0 to 6.5
  - **Rochester:** Mt Carroll silt loam, loess (well drained), 4.5% SOM, water pH 6.7
- Two research plots (P and K) at each location
- Previous fertilizer treatments created replicated plots with a range in soil test levels.
  - Rochester: 4 to 24 ppm Bray P1 and 75 to 241 ppm K in 2019
  - Waseca: 2 to 26 ppm Bray P1 and 73 to 208 ppm K in 2019
  - Individual plots were 20 ft wide and were split into two 10 ft wide plots comparing band (in crop row at 5- to 6-inch depth) and broadcast application.
  - Band & broadcast fertilizer applied in the fall at Waseca (band applied after fall tillage) and in the spring prior to pre-plant tillage at Rochester.

# Monthly precipitation by location and year

- 2020
  - dry Apr, then ideal
- 2021
  - Waseca: driest since 1988
  - Roch.: dry Apr, early May and Jun. Spring app
- 2022
  - rainfall distribution not ideal at Waseca
- 2023
  - Waseca: wet May, dry after
  - Roch.: 41% of norm

	Waseca, MN				Rochester			
Month	2021	2022	2023	30-yr norm	2021	2022	2023	30-yr norm
Apr	0.6	3.8	3.7	3.3	1.1	6.5	4.4	3.5
May	2.7	4.7	6.5	4.5	4.3	5.1	3.6	4.6
Jun	2.0	4.4	1.6	5.4	1.8	4.7	0.2	5.8
Jul	2.7	4.6	1.6	4.9	4.8	4.5	1.4	4.4
Aug	4.8	5.5	3.3	4.8	8.0	5.9	0.9	4.2
Sep	1.9	0.8	2.2	4.1	2.4	0.1	3.2	3.8
May-Sep	14.1	20.0	15.1	23.7	21.3	20.4	9.4	22.8



# Band vs broadcast K at Waseca, June 23, 2020



60 lb  $K_2O$ /ac broadcast on left, banded right (STK=90 ppm)



60 lb  $K_2O$ /ac broadcast on left, banded right (STK=85 ppm)



# Effects of K treatments on soil test K (STK), ear leaf K and corn yield in 2020

- K fertilizer rate: 45 or 60 lb K<sub>2</sub>O/ac) as 0-0-60
- Waseca: yield response to STK/K rate
  - Band ≈ broadcast
  - Annual 120-lb had >> ear leaf K concentration and greater yield
- Rochester: yield response to fertilizer placement
  - Band K > broadcast
  - Band K at 45/60 lb K<sub>2</sub>O/ac = annual broadcast at 120-lb

Location/treatment	STK Jun '19	Ear leaf K	Grain yield
	ppm	%	bu/ac
<u>Waseca</u>			
Banded K	103	1.00	235
Broadcast (bcast)	102	0.93	231
60 lb K <sub>2</sub> O/ac bcast*	121	0.99	229
120 lb K <sub>2</sub> O/ac bcast*	151	1.66	241
<u>Rochester</u>			
Banded K	103	1.27	233A
Broadcast	106	1.22	227B
60 lb K <sub>2</sub> O/ac bcast*	119	1.52	230
120 lb K <sub>2</sub> O/ac bcast*	216	2.07	232
* Applied annually since 2012			

# Effects of P treatments on soil test P (Bray P1), ear leaf P and corn yield in 2020

- P fertilizer rate: 30 or 45 lb P<sub>2</sub>O<sub>5</sub>/ac as 0-45-0 (TSP)
- Waseca: Band = broadcast for all parameters
- Rochester: no yield response to placement
  - Band > broadcast for STP in 2020 (after P applied)
  - Broadcast > band for ear leaf P concentration
  - Leaf P at Roch >> Waseca

Location P Placement	Bray P1 Jun 2019	Bray P1 Jun 2020	Ear leaf P conc.	Grain yield
	ppm	ppm	%	bu/ac
<b><u>Waseca</u></b>				
Banded P	7.7	10.9	0.23	221
Broadcast	7.4	9.8	0.23	220
<b><u>Rochester</u></b>				
Banded P	7.1	12.3A	0.32B	227
Broadcast	7.0	9.5B	0.35A	226

# Band vs broadcast K at Waseca, July 8, 2021



60 lb K<sub>2</sub>O/ac, Broadcast, STK=84 ppm  
photo credit Vetsch



60 lb K<sub>2</sub>O/ac, Banded STK=80 ppm

# Effects of K treatments on soil test K (STK), ear leaf K and corn yield in 2021

- Band vs broadcast averaged across K<sub>2</sub>O rates from 30 to 60 lb/ac
- Waseca: no yield response to STK/K rate or fertilizer placement
  - Annual 120-lb had >> STK and ear leaf K concentration but yields were equal. Drought was likely yield limiting.
- Rochester: yield response to placement and STK/K rate
  - Yield with band < broadcast
  - Annual 120-lb had >> ear leaf K concentration and numerically greater yields

Location/treatment	STK Jun '21	Ear leaf K	Grain yield
	ppm	%	bu/ac
<u>Waseca</u>			
Banded K	94	1.13A	207
Broadcast (bcast)	95	1.09B	205
<u>Rochester</u>			
Banded K	91	1.48	229B
Broadcast	90	1.46	233A
60 lb K <sub>2</sub> O/ac bcast*	94	1.48	232
120 lb K <sub>2</sub> O/ac bcast*	157	1.97	237
* Applied annually since 2012			



# Effects of P treatments on soil test P (Bray P1), ear leaf P and corn yield in 2021

- P fertilizer rate: 30 or 45 lb P<sub>2</sub>O<sub>5</sub>/ac as 0-46-0 (TSP)
- Waseca: no yield effects
  - Band > broadcast for STP
- Rochester: no response
  - Ear leaf P concentration at Roch > Waseca

Location P Placement	Bray P1 Jun 2021	Ear leaf P conc.	Grain yield
	ppm	%	bu/ac
<b><u>Waseca</u></b>			
<b>Banded P</b>	12.8A	0.24	185
<b>Broadcast</b>	9.4B	0.24	184
<b><u>Rochester</u></b>			
<b>Banded P</b>	10.5	0.33	225
<b>Broadcast</b>	10.3	0.33	227

# K deficiency at Waseca, July 1, 2022



K deficient, 30 lb K<sub>2</sub>O/ac, STK=103 ppm  
**176 bu/ac**



healthy, annual 120 lb K<sub>2</sub>O/ac, STK=191 ppm  
**193 bu/ac**

# Effects of K treatments on soil test K (STK), ear leaf K and corn yield in 2022

- Band vs broadcast averaged across K<sub>2</sub>O rates from 30 to 60 lb/ac
- Waseca: no yield response to STK/K rate or fertilizer placement
  - Annual 120-lb had >> STK and ear leaf K, yields were slightly greater
  - Drought + CRW feeding and lodging reduced yields
- Rochester: yield response to placement
  - Band K > broadcast
  - Annual 120-lb had >> STK and ear leaf K concentration
  - STK at Roch < Waseca but ear leaf K at Roch > Waseca

Location/treatment	STK Jun '22	Ear leaf K	Grain yield
	ppm	%	bu/ac
<u>Waseca</u>			
Banded K	125	0.94A	182
Broadcast (bcast)	126	0.90B	181
60 lb K <sub>2</sub> O/ac bcast*	125	0.93	181
120 lb K <sub>2</sub> O/ac bcast*	190	1.43	188
<u>Rochester</u>			
Banded K	112	1.58	230A
Broadcast	114	1.55	222B
60 lb K <sub>2</sub> O/ac bcast*	115	1.60	228
120 lb K <sub>2</sub> O/ac bcast*	208	2.33	228
* Applied annually since 2012			

# Effects of P treatments on soil test P (Bray P1), ear leaf P and corn yield in 2022

- P fertilizer rate: 30 or 45 lb P<sub>2</sub>O<sub>5</sub>/ac as 0-45-0 (TSP)
- Waseca: no differences
- Rochester: yield response
  - Broadcast 5 bu/ac > band
  - Ear leaf P concentration at Roch > Waseca

Location P Placement	Bray P1 Jun 2022	Ear leaf P conc.	Grain yield
	ppm	%	bu/ac
<b><u>Waseca</u></b>			
Banded P	14.3	0.23	190
Broadcast	13.3	0.24	191
<b><u>Rochester</u></b>			
Banded P	13.0A	0.32	204B
Broadcast	10.9B	0.33	209A



# Effect of P fertilization and initial soil test P on change in soil test P and corn yield at Waseca.

- In 2022, 9 bu/ac range in yield from the control treatments (zero P) to the “Very High” Bray P.
- Averaged across 3-years (2020–2022), an 11 bu/ac range, very similar.

P <sub>2</sub> O <sub>5</sub> rate, lb/ac; # of year (yr)	Bray P1, ppm		Grain Yield, bu/ac	
	2019	2022	2022	2020-22
0 lb/ac for 4 yr <sup>13</sup>	17	11	184 <sub>de</sub>	197
0 lb/ac for 4 yr <sup>16</sup>	18	11	190 <sub>abcd</sub>	203
0 lb/ac for 3 yr <sup>14</sup> , 100 lb/ac in 2022	25	32	193 <sub>ab</sub>	208

# Effect of P fertilization and initial soil test P on change in soil test P and corn yield at Rochester.

- In 2022 AND averaged across 3-years (2020–2022), only a 5 bu/ac range in yield from the control treatments (zero P) to the “Very High” Bray P.

P <sub>2</sub> O <sub>5</sub> rate, lb/ac; # of year (yr)	Bray P1, ppm		Grain Yield, bu/ac	
	2019	2022	2022	2020-22
0 lb/ac for 4 yr <sup>13</sup>	13	8	206bc	216
0 lb/ac for 4 yr <sup>16</sup>	15	9	207abc	216
0 lb/ac for 3 yr <sup>14</sup> , 100 lb/ac in 2022	21	14	211abc	221

# Three-year corn summary

- Potassium
  - **Waseca:** no significant yield response to K placement in any year
  - **Rochester:** band yield > broadcast in 2 of 3 years, opposite response in 1 year
  - The annual 120 lb K<sub>2</sub>O/ac treatment increased corn yield in 2 of 6 site-years.
- Phosphorus
  - Broadcast yield > band in 1 of 6 site years (Rochester), all others were NS
- Reducing P and K fertilizer rates
  - Often reduced rates produced equal yields compared with greater rates or treatments with high or very high soil test levels.
  - When P or K rates were reduced soil test levels either declined from high levels to medium OR stayed at low or medium levels. Rochester STK declined
  - Ear leaf P and K concentrations were less at Waseca (clay loam) than at Rochester (silt loam), even though soil test levels were often greater at Waseca



# Recommendation

- Does placement of P and K fertilizer matter?
  - **No**, for P on these soils in this recent study
  - **Yes**, for P on high pH soils & in some older studies or with starter
  - These data showed banding K below the row was occasionally better than broadcast.
- Should I go out and buy a banding implement?
  - **ONLY** if you are planning to switch to strip tillage.
- Can I make more money **banding** reduced rates of P & K?
  - **DEPENDS: yes**, but economics are driven more by applying reduced rates than by a yield increase.
  - Are you and your fertilizer retailer comfortable with low to medium soil test values?
  - What are the effects on soybeans in rotation?



# Did placement of fertilizer for corn affect soybean yield in 2023? NOT MUCH

- 7 to 9 bu/ac range in soybean yields due to wide range in STK
  - K fertilizer placement for corn did not affect soybean yields
- 8 bu/ac range in yield at Waseca and 2 bu/ac yield advantage for band over broadcast.

Location	Soil test range	Soybean yield range	Band vs Broadcast
	<b>Exch. K, ppm</b>	<b>Bu/ac</b>	<b>Yield diff?</b>
<b>Waseca K</b>	87 – 176	56 – 63	NO
<b>Rochester K</b>	78 – 184	39 – 48 <sup>^</sup>	NO
	<b>Bray P1, ppm</b>	<b>Bu/ac</b>	<b>Yield diff?</b>
<b>Waseca P</b>	5 – 27	50 – 58	Band>Bcast
<b>Rochester P</b>	6 – 17	40 – 44 <sup>^</sup>	NO
	<sup>^</sup> Hail damaged		



# Partial economic return (Rank) for K at Waseca

- The cost of potash fertilizer had little affect on net return (rank).
- Treatments with the greatest net return rank had initial soil test K of 120-140 ppm and received modest to low rates of K fertilizer.
  - These low rates of potash generally maintained soil test K
- The annual 60 lb K<sub>2</sub>O/ac treatment was one of the lowest ranking treatments.

Fertilizer Rate			Yield	Net return		Soil test K	
2020	2021-22	3-yr total	3-yr avg	Rank at ^		2019	2022
----- lb K <sub>2</sub> O/ac -----			bu/ac	\$400	\$800	----- ppm -----	
60	60	180	206	<b>8</b>	<b>8</b>	97	109
45	45	135	201	<b>12</b>	<b>11</b>	104	111
0	60	120	207	<b>6</b>	<b>6</b>	131	133
0	45	90	211	<b>3</b>	<b>3</b>	122	134
60	60	180	205	<b>10</b>	<b>9</b>	101	108
<b>60</b>	<b>60</b>	<b>180</b>	<b>202</b>	<b>11</b>	<b>12</b>	<b>139</b>	<b>125</b>
0	30	60	203	<b>9</b>	<b>7</b>	136	116
0	30	60	206	<b>5</b>	<b>5</b>	153	130
45	45	135	213	<b>2</b>	<b>2</b>	121	125
0	30	60	212	<b>1</b>	<b>1</b>	138	134
<b>120</b>	<b>120</b>	<b>360</b>	<b>210</b>	<b>7</b>	<b>10</b>	<b>161</b>	<b>190</b>
0	30	60	208	<b>4</b>	<b>4</b>	167	151

^ Potash fertilizer price \$400/ton or \$800/ton, corn at \$6.00/bushel.



# Partial economic return (Rank) for K at Rochester

- The cost of potash fertilizer affected the net return rank of the annual 120 lb/ac treatment.
- Treatments with the greatest net return rank had initial soil test K of 145-175 ppm and received modest to low rates of K fertilizer.
  - HOWEVER, these low rates of K decreased soil test K substantially.
- The lowest ranking treatments had soil test K <110 ppm & low yield.

Fertilizer Rate			Yield	Net return		Soil test K	
2020	2021-22	3-yr total	3-yr avg	Rank at ^		2019	2022
---- lb K <sub>2</sub> O/ac ----			bu/ac	\$400	\$800	---- ppm ----	
60	60	180	226	<b>12</b>	<b>11</b>	95	92
45	45	135	226	<b>10</b>	<b>10</b>	110	100
0	60	120	232	<b>3</b>	<b>4</b>	147	114
0	45	90	230	<b>6</b>	<b>5</b>	167	122
60	60	180	228	<b>9</b>	<b>9</b>	98	102
<b>60</b>	<b>60</b>	<b>180</b>	<b>230</b>	<b>7</b>	<b>7</b>	<b>119</b>	<b>115</b>
0	30	60	225	<b>10</b>	<b>8</b>	149	115
0	30	60	233	<b>1</b>	<b>1</b>	176	129
45	45	135	231	<b>5</b>	<b>6</b>	117	115
0	30	60	231	<b>4</b>	<b>3</b>	147	108
<b>120</b>	<b>120</b>	<b>360</b>	<b>232</b>	<b>8</b>	<b>12</b>	<b>216</b>	<b>208</b>
0	30	60	233	<b>2</b>	<b>2</b>	176	132

^ Potash fertilizer price \$400/ton or \$800/ton, corn at \$6.00/bushel.



# Partial economic return (Rank) for P at Waseca

- The cost of MAP fertilizer had little affect on net return (rank).
- The treatment with the greatest net return rank had the greatest 3-yr average yield and initial soil test P.
- Treatments with the lowest net return rank had the lowest 3-yr average yield and initial soil test P.

Fertilizer Rate				Yield	Net return		Bray P1	
2020	2021	2022	3-yr total	3-yr avg	Rank at ^		2019	2022
----- lb P <sub>2</sub> O <sub>5</sub> /ac -----				bu/ac	\$450	\$900	---- ppm ----	
45	45	45	135	192	<b>15</b>	<b>16</b>	5	14
30	30	30	90	193	<b>14</b>	<b>14</b>	7	13
30	30	30	90	197	<b>13</b>	<b>13</b>	7	13
0	30	30	60	191	<b>16</b>	<b>15</b>	7	11
45	45	45	135	201	<b>9</b>	<b>10</b>	6	15
30	30	30	90	201	<b>7</b>	<b>9</b>	9	15
30	30	30	90	203	<b>3</b>	<b>4</b>	9	13
0	30	30	60	202	<b>4</b>	<b>3</b>	10	13
30	30	30	90	197	<b>12</b>	<b>12</b>	8	15
0	30	30	60	197	<b>11</b>	<b>11</b>	11	13
30	30	30	90	201	<b>6</b>	<b>8</b>	9	15
0	30	30	60	200	<b>8</b>	<b>7</b>	10	14
0	0	0	0	197	<b>10</b>	<b>6</b>	17	11
0	0	100	100	208	<b>1</b>	<b>1</b>	32	32
0	30	30	60	200	<b>5</b>	<b>5</b>	14	16
0	0	0	0	203	<b>2</b>	<b>2</b>	18	11

^ MAP fertilizer price \$450/ton or \$900/ton, corn at \$6.00/bushel.





# Partial economic return (Rank) for P at Rochester

- The cost of MAP fertilizer didn't affect net return (rank) for the high yielding treatments but did for lower yielding treatments.
- The treatment with the greatest net return rank had the greatest 3-yr average yield and initial soil test P.
- Soil test P declined in only 3 treatments even with fertilizer rates that were <50% of crop removal.

Fertilizer Rate				Yield	Net return		Bray P1	
2020	2021	2022	3-yr total	3-yr avg	Rank at ^		2019	2022
----- lb P <sub>2</sub> O <sub>5</sub> /ac -----				bu/ac	\$450	\$900	---- ppm ----	
45	45	45	135	219	<b>8</b>	<b>14</b>	5	12
30	30	30	90	220	<b>3</b>	<b>3</b>	7	11
0	30	30	60	217	<b>9</b>	<b>8</b>	9	10
30	30	30	90	218	<b>6</b>	<b>9</b>	7	11
30	30	30	90	220	<b>2</b>	<b>2</b>	6	10
30	30	30	90	217	<b>10</b>	<b>12</b>	8	12
0	30	30	60	215	<b>13</b>	<b>13</b>	10	11
30	30	30	90	217	<b>7</b>	<b>11</b>	8	14
30	30	30	90	222	<b>1</b>	<b>1</b>	9	15
0	30	30	60	214	<b>15</b>	<b>15</b>	14	15
0	30	30	60	211	<b>16</b>	<b>16</b>	9	11
0	30	30	60	216	<b>11</b>	<b>10</b>	11	14
0	0	0	0	214	<b>12</b>	<b>4</b>	13	8
0	0	100	100	220	<b>4</b>	<b>6</b>	21	15
0	30	30	60	218	<b>5</b>	<b>5</b>	11	10
0	0	0	0	213	<b>14</b>	<b>7</b>	15	9

^ MAP fertilizer price \$450/ton or \$900/ton, corn at \$6.00/bushel.



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