Evaluation of Phosphorus Soil Test Benchmarks

J.L. Henry and R.A. Gares
Department of Soil Science, University of Saskatchewan
Saskatoon, Sask., S7N 0W0

INTRODUCTION AND OBJECTIVES

In recent years, field experiments with phosphorus fertilizer on stubble seeded land in Saskatchewan have suggested that there has been a change in the nature of the phosphorus response curve and that the phosphorus soil test is not recognizing all of the residual fertilizer phosphorus. There have been suggestions that genetic changes with new cultivars, interactions with herbicides or soil mycorrhizae may be responsible for a fundamental change in the nature of the phosphorus response.

The objective of this study was to accurately document the nature of the phosphorus response curve to CPS wheat over a wide range of available soil phosphorus levels. The study was directed primarily at irrigated conditions but at the lowest soil phosphorus site dryland comparisons were also included.

METHODS

Selection of sites for the experiments was based on a prescreening sampling of the soil. At each prospective site, the area required was staked and a duplicate set of 0-15 cm samples was obtained. The prospective area was split into two and a composite set of samples was obtained from each portion. Based on the prescreening soil samples, seven experimental sites were selected for investigation. Sites were selected for study only if the duplication was good in the prescreening samples. At the selected sites, the exact plot area was staked for a ten times replicated randomized complete block experiment with phosphorus rates of 0, 11, 22, 34, 45 and 90 kg P_2O_5/ha.

Prior to seeding, a duplicate set of 0-15, 15-30 and 30-60 cm soil samples were obtained from the experimental area. One of the sample sets came as a composite of at least fifteen cores from the odd numbered replicates and the second set came from the even numbered replicates. The rigorous prescreening and plot sampling technique ensured that the site was indeed suitable for the intended purpose.

At one of the sites (Hauberg) experiments were laid down on irrigated summerfallow, dryland summerfallow and dryland stubble. The details of the legal location, cooperating farmer, soil association and texture, and complete soil analyses are provided in Table 1. The data in Table 1 show soil test phosphorus values in the 0-15 cm depth varying from 3 to 21 ppm. All soil analyses were conducted by the Saskatchewan Soil Testing Laboratory.

Biggar wheat was planted at 202 kg/ha on dates from May 4 to May 14, 1992, using a double disc press drill with 17.8 cm row spacing. Individual plot size was 7 rows by 17.8 cm wide and 6.1 m in length. The experiment was replicated ten times. The phosphorus source was monoammonium phosphate (11-55-0).

Table 1. Spring soil analyses for phosphorus field experiments

Site	Legal Location	Soil Ass. -texture	Reps.	Depth (cm)	pH	Cond (mS/cm)	N	P	K	S	O.M. %
							--------ppm---------				
Hauberg Summerfall Irrigated	NW24-27-07-W3	E:SiL	Odd	0 - 15	8.3	0.2	12.6	4.1	325	3.4	1.9
				15 - 30	8.5	0.1	5.8	1.5	141	4.6	1.3
				30 - 60	8.8	0.2	5.4	2.4	150	4.8	-
			Even	0 - 15	8.0	0.1	9.8	3.9	256	3.0	1.7
				15 - 30	8.5	0.1	5.4	1.3	131	2.4	1.1
				30 - 60	8.9	0.2	5.8	2.4	143	3.0	-
Hauberg Summerfall Dryland	NW24-27-07-W3	E:SiL	Odd	0 - 15	8.3	0.2	11.0	3.2	320	3.0	1.9
				15 - 30	8.3	0.1	5.0	1.1	137	3.6	1.2
				30 - 60	8.8	0.2	4.0	1.7	146	3.8	-
			Even	0 - 15	8.4	0.1	9.6	3.2	267	2.8	1.6
				15 - 30	8.6	0.1	5.2	1.4	134	2.4	1.2
				30 - 60	8.9	0.2	4.4	2.0	134	3.6	-
Hauberg Stubble Dryland	NW24-27-07-W3	E:SiL	Odd	0 - 15	-	-	3.6	4.3	262	4.2	2.0
				15 - 30	-	-	3.2	2.2	107	4.0	1.4
				30 - 60	-	-	2.8	2.8	119	4.2	-
			Even	0 - 15	-	-	4.0	4.4	320	4.2	2.1
				15 - 30	-	-	3.0	2.3	114	4.0	1.3
				30 - 60	-	-	2.8	2.4	102	7.4	-
SIDC	SW15-29-08-W3	Br:vL	Odd	0 - 15	8.7	0.1	9.2	5.5	246	9.6	1.9
				15 - 30	8.6	0.2	8.8	1.3	130	17.6	1.4
				30 - 60	8.9	0.3	10.6	1.8	114	31.0	-
			Even	0 - 15	8.7	0.2	6.2	4.4	243	11.2	1.8
				15 - 30	8.7	0.2	6.2	1.2	137	14.2	1.1
				30 - 60	8.8	0.3	7.6	1.8	147	36.0	-
Kent	NE10-22-07-W3	Fx:SiL	Odd	0 - 15	7.6	0.1	8.4	6.2	405	4.4	2.8
				15 - 30	8.5	0.2	2.8	1.6	157	5.6	1.9
				30 - 60	8.8	0.2	3.4	2.8	170	7.2	-
			Even	0 - 15	7.3	0.1	6.4	5.4	355	5.0	2.5
				15 - 30	8.5	0.2	2.4	1.4	144	4.4	1.7
				30 - 60	8.9	0.2	3.0	3.3	164	5.4	-
Riley	NW26-29-08-W3	A:fL	Odd	0 - 15	7.7	0.2	10.6	11.0	150	5.4	2.1
				15 - 30	8.7	0.2	6.6	3.4	77	7.0	1.5
				30 - 60	8.8	0.2	9.0	4.7	74	15.4	-
			Even	0 - 15	8.3	0.2	9.0	12.5	163	7.6	2.1
				15 - 30	8.7	0.2	4.6	3.5	72	6.0	1.6
				30 - 60	8.8	0.2	6.6	4.4	68	9.6	-
Tullis	SW15-24-08-W3	Sc:C	Odd	0 - 15	6.7	0.2	10.6	21.3	805	17.8	2.8
				15 - 30	8.3	0.3	3.8	1.9	495	9.4	1.8
				30 - 60	8.3	0.8	2.2	2.9	325	270.0	-
			Even	0 - 15	6.8	0.2	7.4	15.9	710	12.6	2.6
				15 - 30	8.5	0.3	3.2	1.8	375	8.0	1.6
				30 - 60	9.0	0.3	2.4	2.4	315	16.2	-

At all sites a blanket application of 112 kg N/ha was made. At all sites except Kent the application was as surface broadcast ammonium nitrate. At the Kent site 56 kg N/ha had been preplant banded as urea by the farmer and we applied an additional surface broadcast of 56 kg N/ha as ammonium nitrate.

Weed control was accomplished by appropriate herbicides as and when required and all plots were weed free.

At about the two to three-leaf stage, plant counts were made from 3 meters of row in 5 of the 10 replicates. At harvest time, grain samples were removed from the center three rows of the seven row plots over a 3 meter length. Samples were cut at the soil surface. After drying, total sample weight was obtained. Straw weight was taken as the difference between total and grain weight.

At harvest, soil samples were taken from the row and interrow positions from 5 replicates of the 0, 45, and 90 kg P_2O_5/ha rates. Each sample was from the 0-15 cm depth and was a composite of at least 12 cores.

RESULTS AND DISCUSSION

The plant count data are presented in Table 2. Reductions in plant stand were evident, particularly for the 45 and 90 kg P_2O_5/ha rates.

Table 2. Plant count data for the phosphorus experiments (plants per 3 meters of row).

Site	------- P_2O_5 seed placed (kg/ha) -------				$LSD_{0.10}$
	0	22	45	90	(plants per 3 meters)
	Mean Plant Counts				
Hauberg Summerfallow Irrigated	176	169	149	140	12.7
Hauberg Summerfallow Dryland	177	173	158	138	11.8
Hauberg Stubble Dryland	178	166	167	143	7.0
SIDC	177	170	163	155	15.4
Kent	167	159	165	157	N.S.
Riley	154	159	152	136	N.S.
Tullis	205	202	186	189	14.7

The yield data (Table 3) showed clearly that phosphorus was a serious limiting factor to growth for soils testing less than 5 ppm. phosphorus in the 0-15 cm depth. Grain yield responses up to 2000 kg/ha were obtained under very low soil phosphorus test conditions (Hauberg site). At the highest phosphorus test site (Tullis) where the soil phosphorus level was 18.6 ppm., the phosphorus response was very small.

Table 3. Yield data for the P experiments (Biggar wheat).

Site	Soil P Spring (ppm-0-15cm)	P2O5 seed placed (kg/ha)	Grain yield (bu/acre)	------Yield------- (kg/ha) Grain	Straw	$LSD_{0.10}$ (kg/ha) Grain	Straw	Harvest Index
Hauberg	3.2	0	34	2262	2375			0.49
Dryland		11	44	2972	2941			0.50
Summerfall.		22	50	3358	3224			0.51
		34	55	3694	3440			0.52
		45	60	4059	3695			0.52
		90	65	4372	4058	249	236	0.52
Hauberg	3.6	0	68	4586	4564			0.50
Irrigated		11	79	5309	5641			0.48
Summerfall.		22	88	5884	6260			0.48
		34	92	6175	6664			0.48
		45	98	6565	6938			0.49
		90	98	6576	6930	344	439	0.49
Hauberg	4.4	0	31	2098	2128			0.50
Dryland		11	36	2445	2497			0.49
Stubble		22	41	2772	2783			0.50
		34	45	3034	3037			0.50
		45	48	3239	3100			0.51
		90	51	3455	3406	228	242	0.50
SIDC	5.0	0	44	2928	4904			0.37
		11	52	3470	5523			0.39
		22	59	3979	6220			0.39
		34	59	3956	6500			0.38
		45	64	4305	6538			0.40
		90	72	4848	6715	494	346	0.42
Kent	5.8	0	60	4005	4896			0.45
		11	60	4044	4884			0.45
		22	63	4261	5368			0.44
		34	65	4370	5375			0.45
		45	66	4434	5535			0.44
		90	70	4671	5863	316	410	0.44
Riley	11.8	0	59	3979	6519			0.38
		11	67	4493	6595			0.41
		22	65	4363	6825			0.39
		34	67	4506	7035			0.39
		45	72	4826	6935			0.41
		90	75	5060	7304	614	398	0.41
Tullis	18.6	0	74	4960	5735			0.46
		11	72	4832	5811			0.45
		22	72	4864	6012			0.45
		34	77	5148	6231			0.45
		45	78	5270	6403			0.45
		90	77	5197	6409	261	394	0.45

At the Kent site with the soil phosphorus level at less than 6 ppm., the expected response would be greater than the response actually observed. At that site the final grain protein (data not shown) was only 10% and the straw nitrogen only 0.3% indicating that

nitrogen was a limiting factor in the eventual yield potential and would preclude the maximum phosphorus response.

Soil sampling at harvest (Table 4) showed a very large effect of sampling position on available phosphorus.

Table 4. Soil analysis in the phosphorus experiments from row and inter-row samples of three selected treatments (kg P_2O_5/ha seed placed) - sampled on harvest date.

Site	Soil P Spring (ppm-0-15cm)	-------Row ------ 0	45	90	-----Inter-row----- 0	45	90	$LSD_{0.01}$ (ppm - 0-15 cm)
		---Fall soil phosphorus (ppm - 0-15 cm)---						
Hauberg Dryland Summerfallow	3	3	11	20	2	3	3	7.5
Hauberg Irrigated Summerfallow	4	3	7	23	3	5	6	4.7
Hauberg Dryland Stubble	4	3	13	28	3	3	4	6.1
SIDC	5	6	8	16	6	6	6	4.8
Kent	6	5	15	30	7	6	8	5.1
Riley	12	10	14	21	11	12	13	3.9
Tullis	19	14	24	33	17	20	22	8.6

CONCLUSIONS

Based on the data presented herein, it is concluded that the phosphorus test currently being used by the Saskatchewan Soil Testing Laboratory is sound and with minor modifications can be used into the future. For row applied phosphorus, soil sampling position must be considered in subsequent soil testing programs.