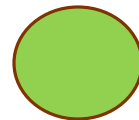
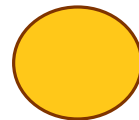
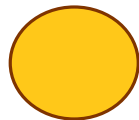
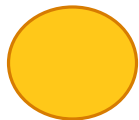
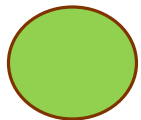


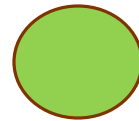
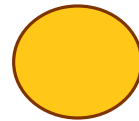
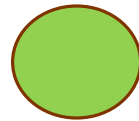
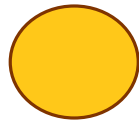
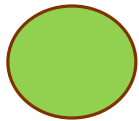
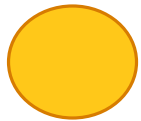
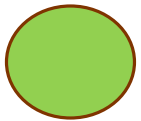
# P-guidelines for Maize - 2016 -

FertASA Symposium  
Pretoria  
27 July 2016

Dr Chris Schmidt



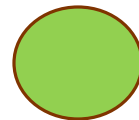
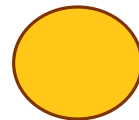
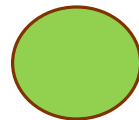
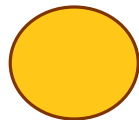
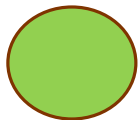
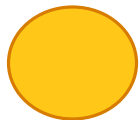
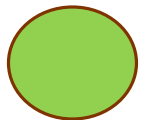
# The Fruit of our Labour!



**Pre-1996 a committee decided on the need for new P-guidelines (maize; +20 years ago).**

**During that time the Grain Crops Institute (Potchefstroom) commenced with a project named "P-calibration studies".**

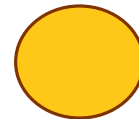
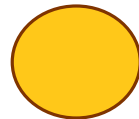
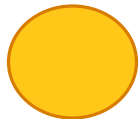
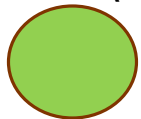
**Until recently the following Table was still proposed by the FSSA in their Fertilizer Handbook as the relevant P-guideline.**



## The "Old" P-guideline

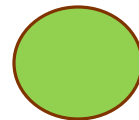
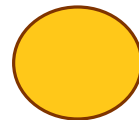
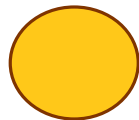
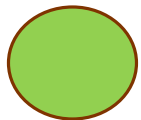
Soil-P (Bray1)	P-recommendation for yield potentials of (t/ha)									Comments on soil-P
	2	3	4	5	6	7	8	9	10	
mg/kg	kg/ha									
0 - 4	20	42	65	88	109	130	130	130	130	Sub-optimal: Build-up and maintenance (crop removal)
5 - 7	17	31	47	63	67	90	93	95	97	
8 - 14	13	19	30	42	50	59	64	67	68	
15 - 20	10	13	21	29	36	42	47	50	53	
21 - 27	7	10	15	19	26	31	34	38	41	Optimal ←
28 - 34	6	9	12	15	18	22	24	27	30	Higher than optimal: Maintenance

FSSA (2007)



## Many reasons for the need of a new guideline:

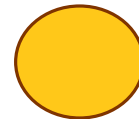
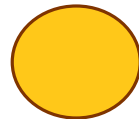
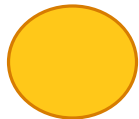
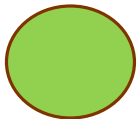
- the "old" one derived "over" soils (soils properties excluded),
- soils samples used for data not always obtained at same soil depth,
- P-fertilizer either broadcasted or band-placed
- etc.



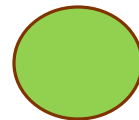
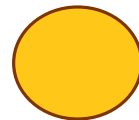
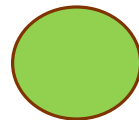
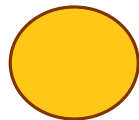
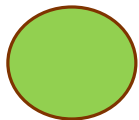
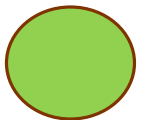
During 2003 the P-calibration studies project ended with a final report as a PhD-dissertation (13 years ago).

namely

“Changes in the Phosphorus status of soils and the influence on maize yield”

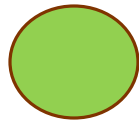
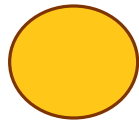
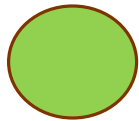
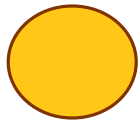
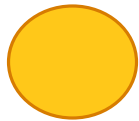
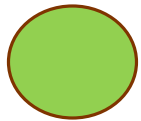


**Today, we celebrate the partial inclusion of the P-calibration study in the 2016 FertASA Fertilizer Handbook.**



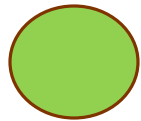
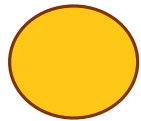
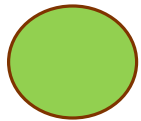
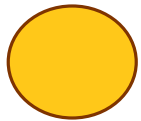
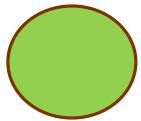
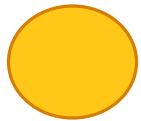
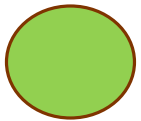
# *P, what is your name?*

*(a name is an extension of character)*



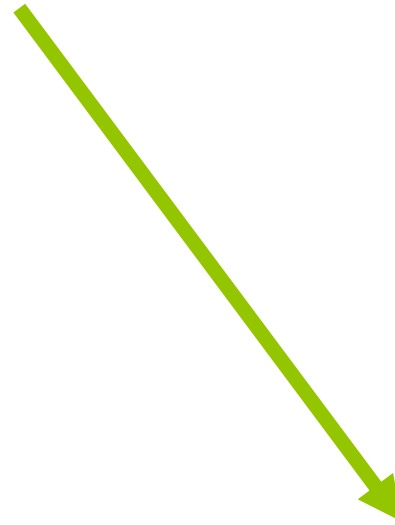
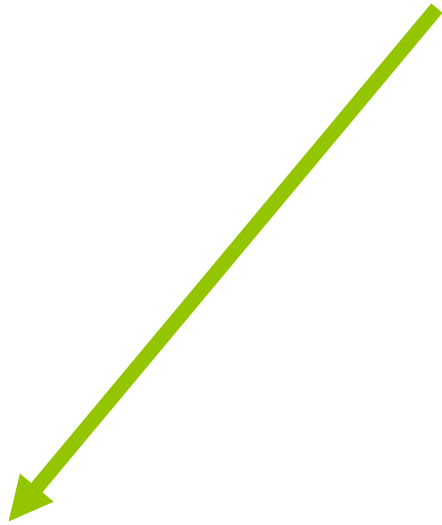
- C.D. -

**- C.D. -**



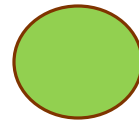
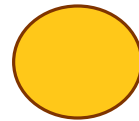
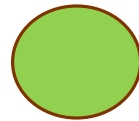
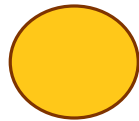
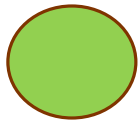
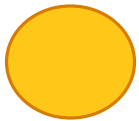
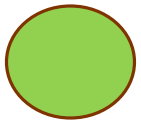
- C.D. -

**C.D.**



**Concentration**

**Diffusion (incl. root contact)**



C.D. (P) is also involved in relationships in the soil:

- Mainly with three elements, i.e. Ca, Fe + Al.
- Depends on the soil-pH.
- Will determine P-efficacy in soil (on agronomic level).
- Because of soil properties, interactions will vary and will not be equally strong.
- PRF's (P-requirement factors)
  - The amount of P per hectare needed to increase soil-P-value ( $\text{mg kg}^{-1}$ ; Bray 1) with one  $\text{mg kg}^{-1}$ .

P-requirement factors		
Clay %		
<10	10-20	21-35
5	7	9

ARC-GCI (2012)

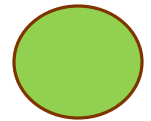
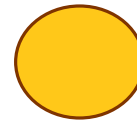
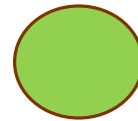
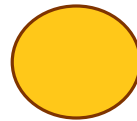
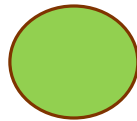
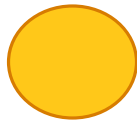
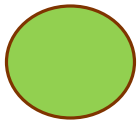
Guideline explained by



4 Tables

- ▶ **Table 1:** Evaluate the soil
- ▶ **Table 2:** Manipulation of soil-P-values (~~"Corrections"~~)
- ▶ **Table 3:** P-application to be banded with planting (2-12 t ha<sup>-1</sup>)
- ▶ **Table 4:** P-application to be applied (broadcasted) beforehand and banded with planting (7-20 t ha<sup>-1</sup>)

Adapted from Schmidt (2003)



## Guideline explained by – cont.

- **Table 1:** Critical P-values
- **Table 2:** P-applications needed to “adjust/manipulate” shortages in topsoil (depth not defined) according to Bray 1 values, clay + silt content (sample density indication) in order to obtain 95% relative yield.
- **Table 3:** P-applications to be band-placed at planting, based on Bray 1 values and clay + silt content (sample density indication), as well as target maize yield (2-12 t ha<sup>-1</sup>).
- **Table 4:** P-applications to be BOTH broadcasted beforehand and band-placed at planting, based on Bray 1 values, sample density and clay + silt content, as well as target maize yield (7-20 t ha<sup>-1</sup>).

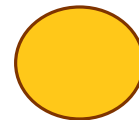
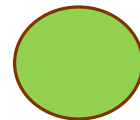
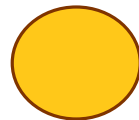
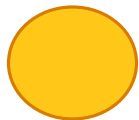
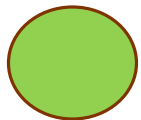


Table 1



Critical P-values



Concentration and quantity of extractable P needed in top 150 mm of soil for 95% relative yield at different clay and silt content (density).



Purpose



Evaluate the soil

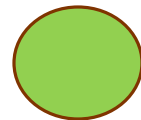
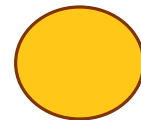
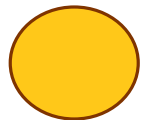
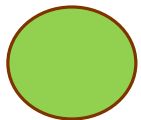
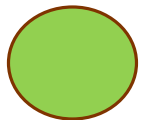
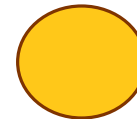
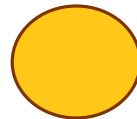
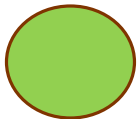


Table 1 – cont.

Clay + Silt range	Approx. associated sample density for applicable Clay + Silt range <sup>#</sup>	Critical P-values (Bray 1) in top 150 mm soil layer needed for 95% relative yield at applicable Clay + Silt range	
%	g cm <sup>-3</sup>	Concentration in 0-150 mm layer mg P kg <sup>-1</sup>	Quantity in 0-150 mm layer kg P ha <sup>-1</sup> ##
10-15	1.539 – 1.469	36	82
16-20	1.455 – 1.404	32	74
21-25	1.391 – 1.344	28	67
26-30	1.332 – 1.289	26	60
31-35	1.278 – 1.239	24	55
36-40	1.229 – 1.194	23	50
41-45	1.185 – 1.154	22	46
46-50	1.146 – 1.119	21	43
51-55	1.112 – 1.089	21	40
56-60	1.083 – 1.064	20	37

# sample density provides a good indication of Clay + Silt - is a less costly procedure, but less accurate

## kg ha<sup>-1</sup> = concentration (mg kg<sup>-1</sup>) x sample density (g cm<sup>-3</sup>) x depth (mm)/100

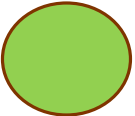


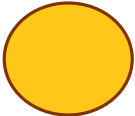
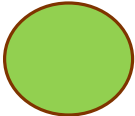
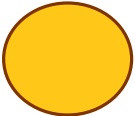



Important:

Table 1 cont.

- Concentrations ( $\text{mg kg}^{-1}$ ) are only applicable to the 0-150 mm soil depth with deeper zones containing little/no P.
- Quantities can be extrapolated to P-content for deeper zones.
- Thus 0-150 mm depth guideline does not need to limit interpretation.
- Avoid comparing deeper soil depth concentrations directly with guideline's values. For that purpose extrapolate (use  $\text{kg ha}^{-1}$ ).
- Example below:

Sample density $\text{kg m}^{-3}$	P-concentration ( $\text{mg kg}^{-1}$ ) in different soil depths (mm)				P-quantity ( $\text{kg ha}^{-1}$ ) in different soil depths (mm)			
	0-150	0-200	0-250	0-300	0-150	0-200	0-250	0-300
1350	15				30	41	51	61
	15	11	9	7	30			

## Table 2

**P-applications needed to "adjust/manipulate" shortages in topsoil (depth not defined) according to Bray 1 values and clay + silt content (sample density indication) in order to obtain 95% relative yield.**

Purpose



Manipulation + crop removal

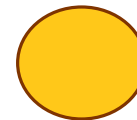
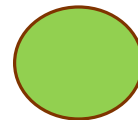
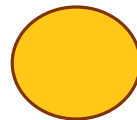
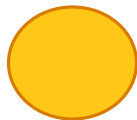
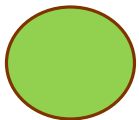


Table 2 – cont.

Clay + Silt range %	Approx. associated sample density range <sup>#</sup> for mentioned clay + silt range <sup>#</sup> g cm <sup>-3</sup>	<u>Measured P</u> in topsoil (Bray 1; mg kg <sup>-1</sup> ) for different soil depths				<u>P-application</u> needed to adjust soil-P-status kg P ha <sup>-1</sup>
		Soil depth (mm)				
		0-150	0-200	0-250	0-300	
10-20	1.539 – 1.404	2	2	1	1	166
		7	5	4	4	144
		12	9	7	6	122
		16	12	10	8	100
		21	15	12	10	78
		25	19	15	13	56
		30	22	18	15	34
		34	26	20	17	12
		39	29	23	19	0

# sample density is a good indicator for clay + silt and a less costly procedure, but less accurate

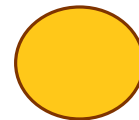
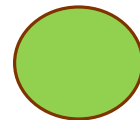
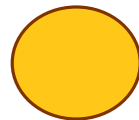
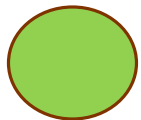
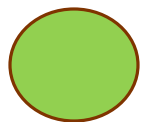
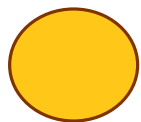
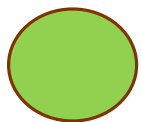
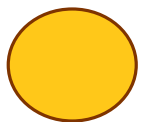
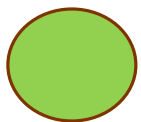
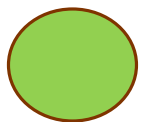


Table 2 – cont.

Clay + Silt range %	Approx. associated sample density range <sup>#</sup> for mentioned clay + silt range <sup>#</sup> g cm <sup>-3</sup>	<u>Measured P</u> in topsoil (Bray 1; mg kg <sup>-1</sup> ) for different soil depths				<u>P-application</u> needed to adjust soil-P-status kg P ha <sup>-1</sup>
		Soil depth (mm)				
		0-150	0-200	0-250	0-300	
21-30	1.391 – 1.289	2	2	1	1	206
		8	6	5	4	171
		13	9	8	6	136
		18	13	11	9	101
		23	17	14	11	66
		27	21	16	14	31
		32	24	19	16	0
31-40	1.278 – 1.194	3	2	2	1	241
		8	6	5	4	191
		13	10	8	7	141
		19	14	11	9	91
		24	18	14	12	41
		29	22	18	15	0

Table 2 – cont.

Clay + Silt range %	Approx. associated sample density range <sup>#</sup> for mentioned clay + silt range <sup>#</sup> g cm <sup>-3</sup>	<u>Measured P</u> in topsoil (Bray 1; mg kg <sup>-1</sup> ) for different soil depths				<u>P-application</u> needed to adjust soil-P-status kg P ha <sup>-1</sup>
		Soil depth (mm)				
		0-150	0-200	0-250	0-300	
41-50	1.185 – 1.119	3	2	2	1	200
		9	6	5	4	150
		14	11	8	7	100
		20	15	12	10	50
		25	19	15	13	0
51-60	1.112 – 1.064	<b>3</b>	2	2	1	<b>168</b>
		9	7	5	4	118
		15	11	9	7	68
		20	15	12	10	18
		<b>26</b>	20	16	13	<b>0</b>



## Table 2 cont.:

### Important:

- P-fertilizer is expensive.
- Therefore, any build-up will be expensive.
- Consider a build-up programme over time and not at once!
- In higher productive and high potential conditions, P-adjustments may be more justifiable.
- In more marginal conditions, P-adjustments may not be justifiable, but be knowledgeable about possible P-restrictions on crop performance.
- Make use of best P-practices.

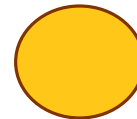
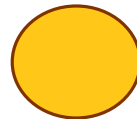
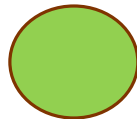
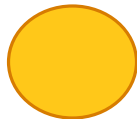
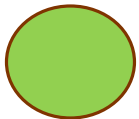


Table 3

P-applications to be band-placed at planting, based on Bray 1 values and clay + silt content (sample density indication), as well as maize yield (2-12 t ha<sup>-1</sup>).

Purpose



P-application to be banded with planting (2-12 t ha<sup>-1</sup>)

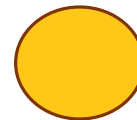
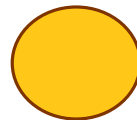
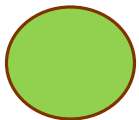


Table 3 – cont.

Approx. associated  
sample density  
range# for  
mentioned clay +  
silt range#

$\text{g cm}^{-3}$

SD

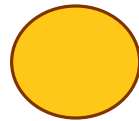
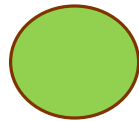
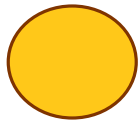
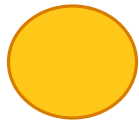
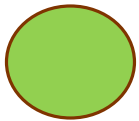


Table 3 – cont.

Clay + Silt range	SD	Measured P in topsoil (Bray 1; mg kg <sup>-1</sup> ) for different soil depths (mm)				Estimated yield (t ha <sup>-1</sup> )										
		0-150	0-200	0-250	0-300	2	3	4	5	6	7	8	9	10	11	12
%	g cm <sup>-3</sup>	mg kg <sup>-1</sup>				P-recommendation										
						kg P ha <sup>-1</sup>										
10-20	1.539 – 1.404	2	2	1	1	16	20	24	28	32	36	40	44	48	52	56
		7	5	4	4	15	19	23	27	31	35	39	43	47	51	55
		12	9	7	6	14	18	22	26	30	34	38	42	46	50	54
		16	12	10	8	13	17	21	25	29	33	37	41	45	49	53
		21	15	12	10	12	16	20	24	28	32	36	40	44	48	52
		25	19	15	13	11	15	19	23	27	31	35	39	43	47	51
		30	22	18	15	10	14	18	22	26	30	34	38	42	46	50
		34	26	20	17	9	13	17	21	25	29	33	37	41	45	49
		39	29	23	19	8	12	16	20	24	28	32	36	40	44	48

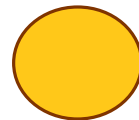
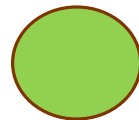
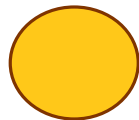
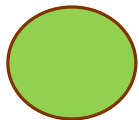
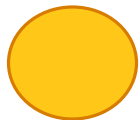
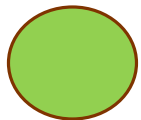


Table 3 – cont.

Clay + Silt range	SD	Measured P in topsoil (Bray 1; mg kg <sup>-1</sup> ) for different soil depths (mm)				Estimated yield (t ha <sup>-1</sup> )										
		0-150	0-200	0-250	0-300	2	3	4	5	6	7	8	9	10	11	12
%	g cm <sup>-3</sup>	mg kg <sup>-1</sup>				P-recommendation										
						kg P ha <sup>-1</sup>										
21-30	1.391 – 1.289	2	2	1	1	17	21	25	29	33	37	41	45	49	53	57
		8	6	5	4	16	20	24	28	32	36	40	44	48	52	56
		13	9	8	6	14	18	22	26	30	34	38	42	46	50	54
		18	13	11	9	13	17	21	25	29	33	37	41	45	49	53
		23	17	14	11	11	15	19	23	27	31	35	39	43	47	51
		27	21	16	14	10	14	18	22	26	30	34	38	42	46	50
		32	24	19	16	8	12	16	20	24	28	32	36	40	44	48
31-40	1.278 – 1.194	3	2	2	1	18	22	26	30	34	38	42	46	50	54	58
		8	6	5	4	16	20	24	28	32	36	40	44	48	52	56
		13	10	8	7	14	18	22	26	30	34	38	42	46	50	54
		19	14	11	9	12	16	20	24	28	32	36	40	44	48	52
		24	18	14	12	10	14	18	22	26	30	34	38	42	46	50
		29	22	18	15	8	12	16	20	24	28	32	36	40	44	48

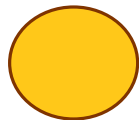
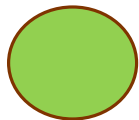
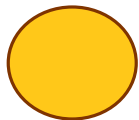
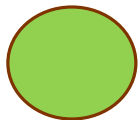
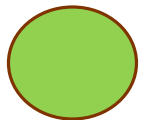
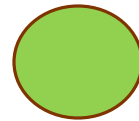
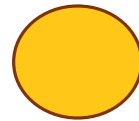
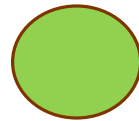
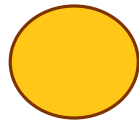
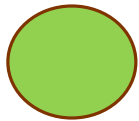
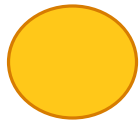
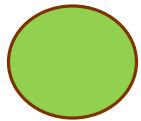


Table 3 – cont.

Clay + Silt range	SD	Measured P in topsoil (Bray 1; mg kg <sup>-1</sup> ) for different soil depths (mm)				Estimated yield (t ha <sup>-1</sup> )										
						2	3	4	5	6	7	8	9	10	11	12
%	g cm <sup>-3</sup>	0-150	0-200	0-250	0-300	P-recommendation										
		mg kg <sup>-1</sup>				kg P ha <sup>-1</sup>										
41-50	1.185 – 1.119	3	2	2	1	20	24	28	32	36	40	44	48	52	56	60
		9	6	5	4	17	21	25	29	33	37	41	45	49	53	57
		14	11	8	7	14	18	22	26	30	34	38	42	46	50	54
		20	15	12	10	11	15	19	23	27	31	35	39	43	47	51
		25	19	15	13	8	12	16	20	24	28	32	36	40	44	48
51-50	1.112 – 1.064	3	2	2	1	24	28	32	36	40	44	48	52	56	60	64
		9	7	5	4	20	24	28	32	36	40	44	48	52	56	60
		15	11	9	7	16	20	24	28	32	36	40	44	48	52	56
		20	15	12	10	12	16	20	24	28	32	36	40	44	48	52
		26	20	16	13	8	12	16	20	24	28	32	36	40	44	48



### Table 3 cont.:

#### Important:

- **Application of guideline straight forward.**
- **Attempted "corrections" of P-deficiencies by broadcasting is not economically viable at row widths of 1.5 m and wider.**
- **It may however be considered at row widths of 1 m and less under lower production practices, over time, on specific small affected areas .**

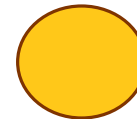
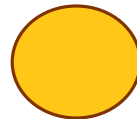
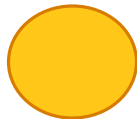
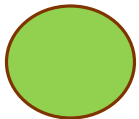


Table 4

P-applications to be BOTH broadcasted beforehand and band-placed at planting, based on Bray 1 values and clay + silt content (sample density indicated), as well as maize yield (7-20 t ha<sup>-1</sup>).

Purpose



P-application to be applied beforehand and banded with planting (7-20 t ha<sup>-1</sup>)



Table 4

Clay + Silt range	SD	Measured P in topsoil (Bray 1; mg kg <sup>-1</sup> ) for different soil depths (mm)				Estimated yield (t ha <sup>-1</sup> )													
		0-150	0-200	0-250	0-300	7	8	9	10	11	12	13	14	15	16	17	18	19	20
%	g cm <sup>-3</sup>	mg kg <sup>-1</sup>				P-recommendation													
						kg P ha <sup>-1</sup>													
10-20	1.539 - 1.404	2	2	1	1	194	198	202	206	210	214	218	222	226	230	234	238	242	246
		7	5	4	4	172	176	180	184	188	192	196	200	204	208	212	216	220	224
		12	9	7	6	150	154	158	162	166	170	174	178	182	186	190	194	198	202
		16	12	10	8	128	132	136	140	144	148	152	156	160	164	168	172	176	180
		21	15	12	10	106	110	114	118	122	126	130	134	138	142	146	150	154	158
		25	19	15	13	84	88	92	96	100	104	108	112	116	120	124	128	132	136
		30	22	18	15	62	66	70	74	78	82	86	90	94	98	102	106	110	114
		34	26	20	17	40	44	48	52	56	60	64	68	72	76	80	84	88	92
		39	29	23	19	28	32	36	40	44	48	52	56	60	64	68	72	76	80
21-30	1.391 - 1.289	2	2	1	1	234	238	242	246	250	254	258	262	266	270	274	278	282	286
		8	6	5	4	199	203	207	211	215	219	223	227	231	235	239	243	247	251
		13	9	8	6	164	168	172	176	180	184	188	192	196	200	204	208	212	216
		18	13	11	9	129	133	137	141	145	149	153	157	161	165	169	173	177	181
		23	17	14	11	94	98	102	106	110	114	118	122	126	130	134	138	142	146
		27	21	16	14	59	63	67	71	75	79	83	87	91	95	99	103	107	111
		32	24	19	16	28	32	36	40	44	48	52	56	60	64	68	72	76	80

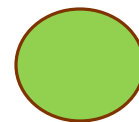
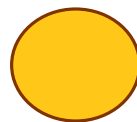
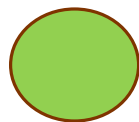
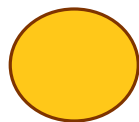
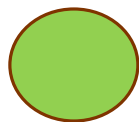
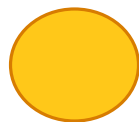
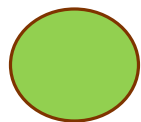
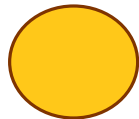
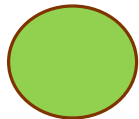
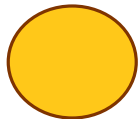
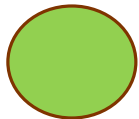
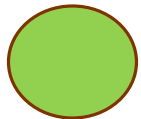


Table 4 – cont.

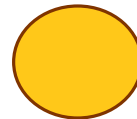
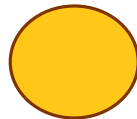
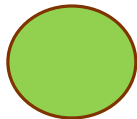
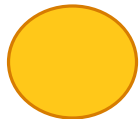
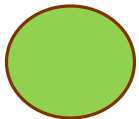
Clay + Silt range	SD	Measured P in topsoil (Bray 1; mg kg <sup>-1</sup> ) for different soil depths (mm)				Estimated yield (t ha <sup>-1</sup> )													
		0-150	0-200	0-250	0-300	7	8	9	10	11	12	13	14	15	16	17	18	19	20
%	g cm <sup>-3</sup>	mg kg <sup>-1</sup>				P-recommendation													
						kg P ha <sup>-1</sup>													
31-40	1.278	3	2	2	1	269	273	277	281	285	289	293	297	301	305	309	313	317	321
		8	6	5	4	219	223	227	231	235	239	243	247	251	255	259	263	267	271
	1.194	13	10	8	7	169	173	177	181	185	189	193	197	201	205	209	213	217	221
		19	14	11	9	119	123	127	131	135	139	143	147	151	155	159	163	167	171
		24	18	14	12	69	73	77	81	85	89	93	97	101	105	109	113	117	121
		29	22	18	15	28	32	36	40	44	48	52	56	60	64	68	72	76	80
41-50	1.185	3	2	2	1	228	232	236	240	244	248	252	256	260	264	268	272	276	280
		9	6	5	4	178	182	186	190	194	198	202	206	210	214	218	222	226	230
	1.119	14	11	8	7	128	132	136	140	144	148	152	156	160	164	168	172	176	180
		20	15	12	10	78	82	86	90	94	98	102	106	110	114	118	122	126	130
		25	19	15	13	28	32	36	40	44	48	52	56	60	64	68	72	76	80
51-50	1.112	3	2	2	1	196	200	204	208	212	216	220	224	228	232	236	240	244	248
		9	7	5	4	146	150	154	158	162	166	170	174	178	182	186	190	194	198
	1.064	15	11	9	7	96	100	104	108	112	116	120	124	128	132	136	140	144	148
		20	15	12	10	46	50	54	58	62	66	70	74	78	82	86	90	94	98
		26	20	16	13	28	32	36	40	44	48	52	56	60	64	68	72	76	80



## Table 4 cont.:

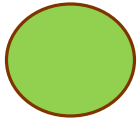
### Important:

- **Application of guideline is straight forward.**
- **At low P-values and high yield expectations, extremely high P-rates are required.**
- **These high rates may not always be economically viable.**
- **In case of low P-values, work rates higher over time, sensitizing client of situation and the purpose of the effort.**
- **If client wishes to adjust immediately to required P-rate, accomodate the desire.**
- **Always communicate the effect of too low P on yield expectation.**



## Final conclusions and remarks

- It is **SOMETHING DIFFERENT**, it is straight forward.
- It may occur as immensely expensive and economically impossible.
- **Did we live in a bubble to believe:  $P\text{-rates} = \text{yield} \times \text{crop removal}$ ?**
- Did we ever considered/incorporated PRF's!
- Did we confuse banded P-efficacy with conservatism?
- We can't work magic impossibilities.
- Always communicate the effect of too low P on yield expectation.
- Remember: The wooden barrel principle (Law of the minimum) applies.
- One of Nature's laws:
  - Matter can't be created, or demolished, but can change shape.
  - In other words – to harvest yield, energy must be applied, either by the soil reserve, or fertilizer application, or both.



**Thank You,**

**may you enjoy and apply CD!**

