New protocol for phosphorus estimation in organically managed acidic soils, Meghalaya, India

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SOILS: WHERE FOOD BEGINS

Global Symposium on Soils for Nutrition | 26-29 July 2022

Introduction:

Phosphorus (P): One of the major plant nutrients.

- **Major functions:** Disease resistance, Root development, Grain formation, Constituents of nucleic acid and phytin, energy currency, etc.
- **Deficiency symptoms:** Dark green coloured leaves, Bronzing appearance, Red-purple coloration, etc.
- **Different P pools:** Soil solution Pi, Labile Pi, Primary and Secondary minerals **(Inorganic)**, Inositol phosphate, Phospholipids, Nucleic acids, Nucleotides, Sugar phosphates **(Organic).**
- **Various forms:** The orthophosphates, $H_2PO_4^-$ (primary) and HPO_4^{2-} (secondary orthophosphate), PO_4^{3-} (tertiary orthophosphate).

- 2.24 mha land in Meghalaya is Acidic.
- Majority of the areas in Meghalaya are by default organic in nature.
- Till 2017, 1,410 hectares of agricultural land have been certified for organic farming in the state.
- Focus to develop the default organic areas.
- Ginger, Turmeric, Pineapple, Cashew, Orange, Vegetables, etc. are organically grown in various areas.
- Organic products are preferred by all.
- **Conventional soil testing methods: Not valid for organically managed soils.**
- The potentially available pools of P in organic soils cannot be extracted by conventional methods.
- Different types of extractants are required to extract the various potentially available pools of P.

Objectives

1) Identification of the suitable organic acid extractants to extract the potentially available insoluble inorganic P pools in acidic soils under organic farming system.

2) Developing a ready-to-use soil testing protocol for potentially available phosphorus dedicated to organic farming.

Experimental details

Locations: Five sites with two soil orders

- **Conventionally managed field (two):** CPGS-AS farm, Umiam and Palwi village, Bhoirymbong (Alfisol).
- **Organically managed field (three):** ICAR farm, Umiam; Krydem village, Bhoirymbong (Alfisol) and CPGS-AS farm, Krydemkulai.

* The sites other than the ones mentioned are of Inceptisol order.

Extractants to be tested for tracking the potentially available P-pools and their sizes in soils of organic production systems:

Five with one check

- Citric acid extractant (Blazer and Blazer-Graf, 1984)
- Acetic acid extractant (Morgan, 1941)
- Lactic acid extractant (Egner-Riehm, 1995; Domingo, 1960)
- Double lactate extractant (Dey *et al.,* 2019)
- 2, keto-glutaric acid extractant (Dey *et al.,* 2019)
- Check: Bray 1 extractant (Bray and Kurtz, 1945).

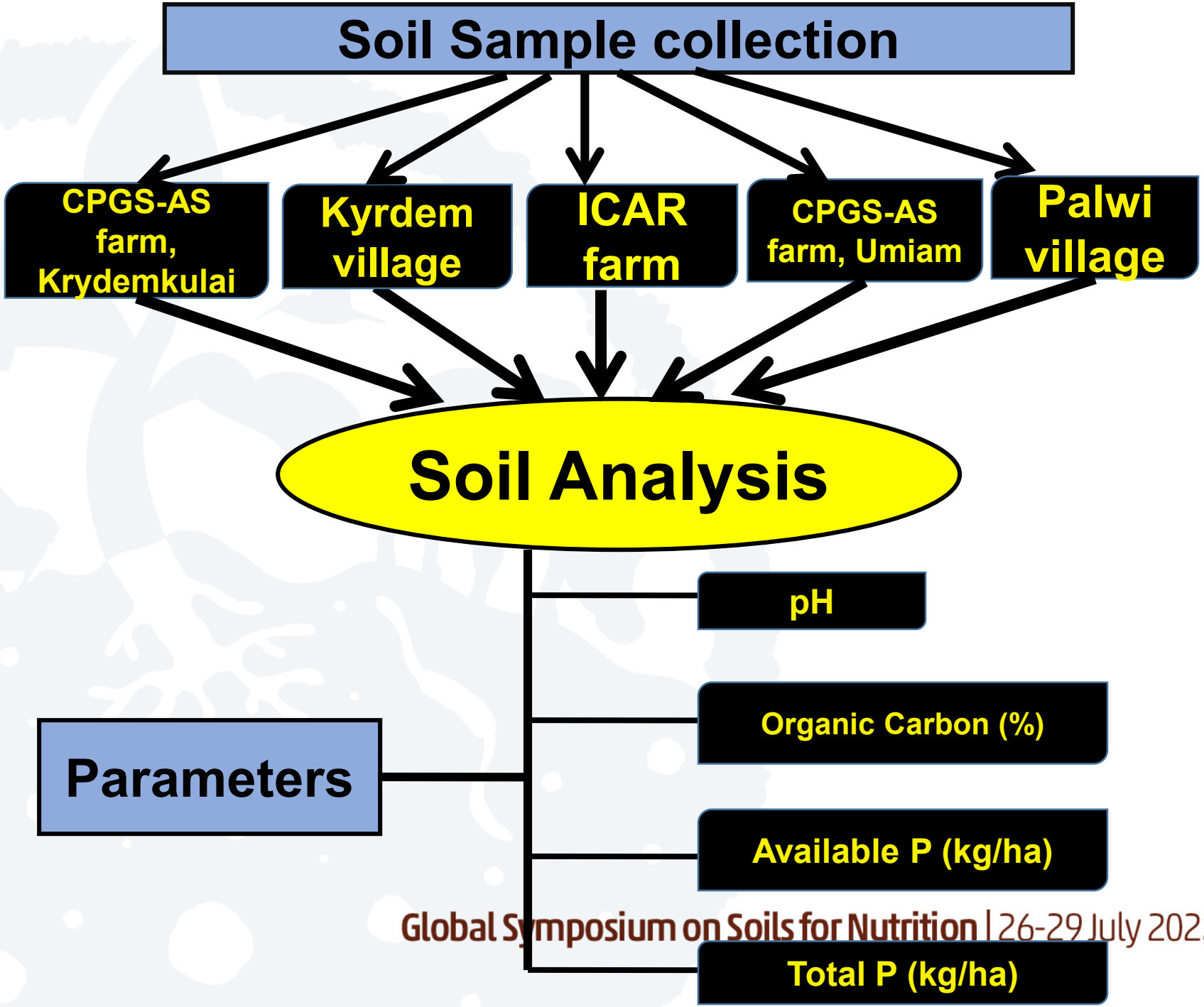
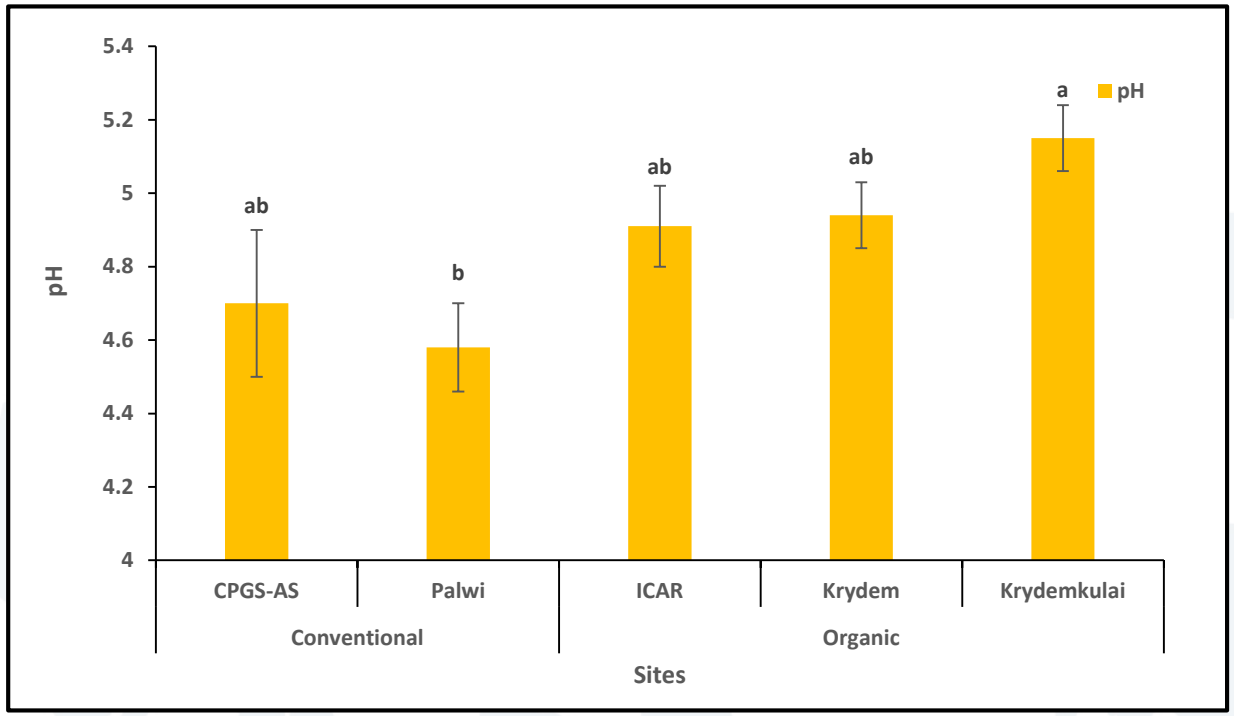
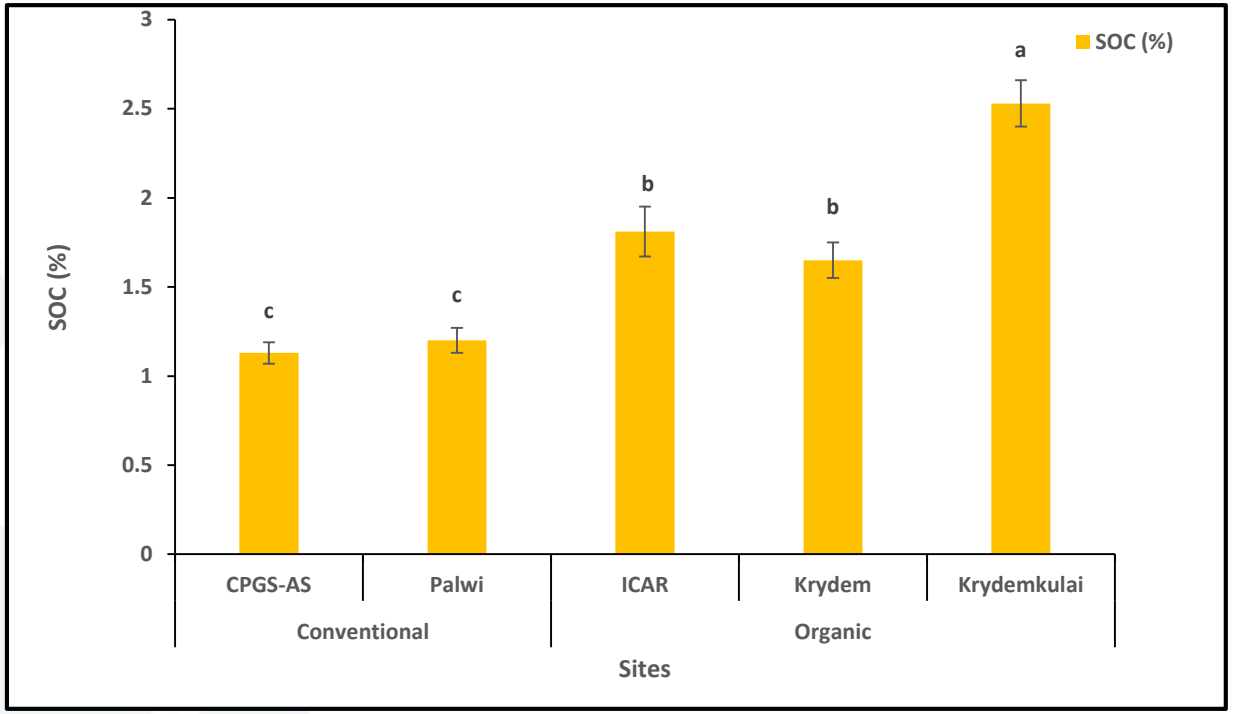

Soil Sample collection
CPGS-AS farm, Krydemkulai
Kyrdem village
ICAR farm
CPGS-AS farm, Umiam
Palwi village
Soil Analysis
Parameters
pH
Organic Carbon (%)
Available P (kg/ha)
Total P (kg/ha)

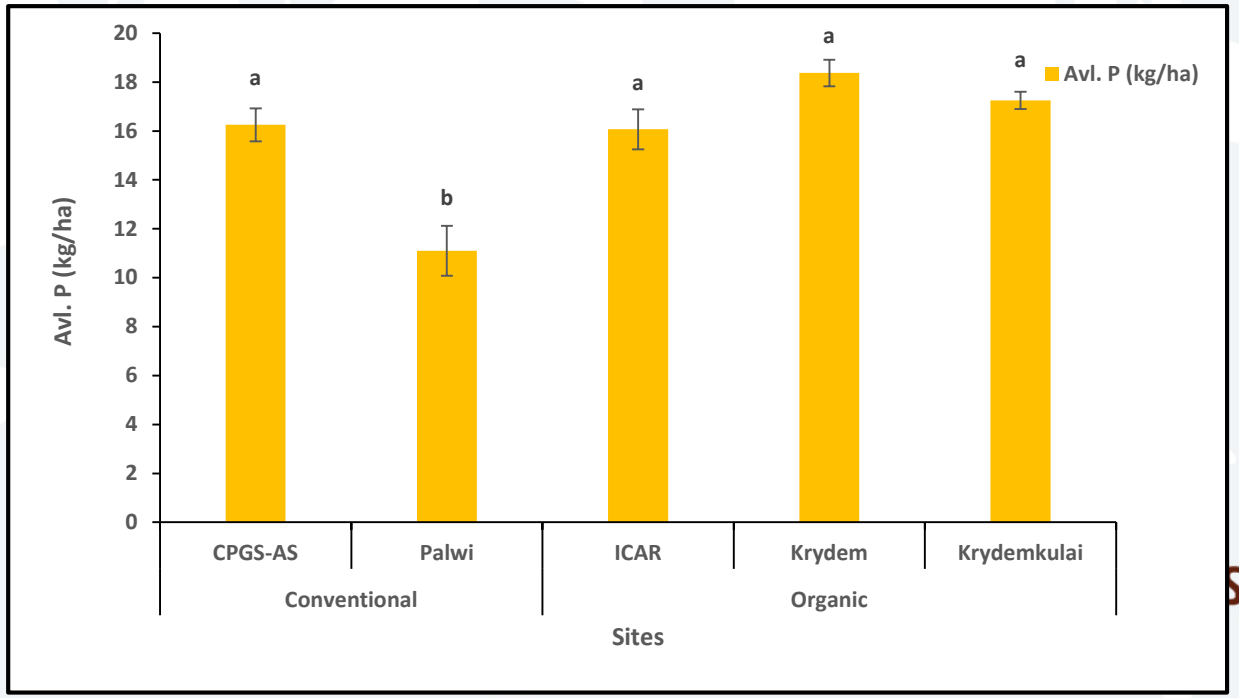
Table 1:Chemical properties of the soil sampling sites

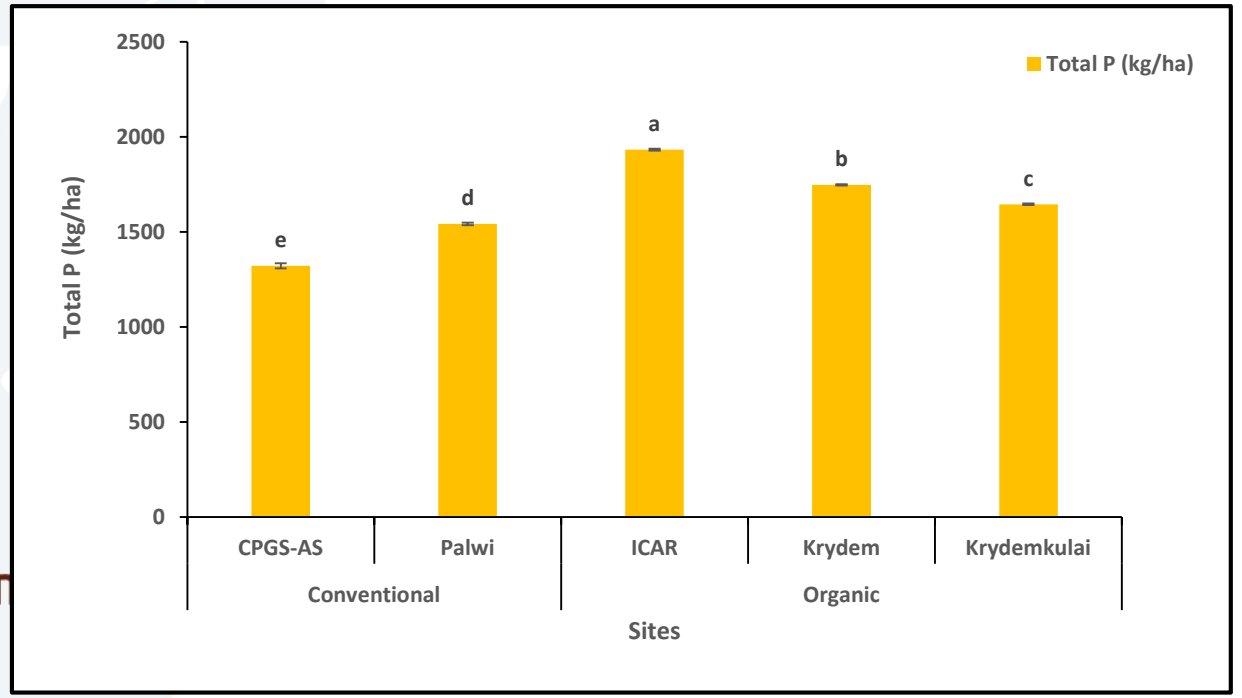
Particulars \ Sites	CPGS-AS farm, Umiam	Palwi village, Bhoirymbong	ICAR farm, Umiam	Kyrdem village, Bhoirymbong	CPGS-AS farm, Krydemkulai
Status	Conventional	Conventional	Organic	Organic	Organic
pH	4.70±0.20ab	4.58±0.12b	4.91±0.11ab	4.94±0.09ab	5.15±0.09a
SOC (%)	1.13±0.06c	1.20±0.07c	1.81±0.14b	1.65±0.10b	2.53±0.13a
Avl. P (kg/ha)	16.25±0.67a	11.1±1.02b	16.07±0.82a	18.37±0.54a	17.25±0.35a
Total P (kg/ha)	1321.58±13.57e	1542.12±6.59d	1933.35±4.30a	1748.18±3.60b	1645.67±4.44c

*Means not sharing the same letters in the same column differs significantly (at p<0.01) by DMRT


pH
5.4
5.2
5
4.8
4.6
4.4
4.2
4
ab
b
ab
ab
a
CPGS-AS
Palwi
ICAR
Krydem
Krydemkulai
Conventional
Organic
Sites


SOC (%)
3
2.5
2
1.5
1
0.5
0
c
c
b
b
a
CPGS-AS
Palwi
ICAR
Krydem
Krydemkulai
Conventional
Organic
Sites


Avl. P (kg/ha)
20
18
16
14
12
10
8
6
4
2
0
a
b
a
a
a
CPGS-AS
Palwi
ICAR
Krydem
Krydemkulai
Conventional
Organic
Sites


Total P (kg/ha)
2500
2000
1500
1000
500
0
e
d
a
b
c
CPGS-AS
Palwi
ICAR
Krydem
Krydemkulai
Conventional
Organic
Sites

Potentially available phosphorus extraction by

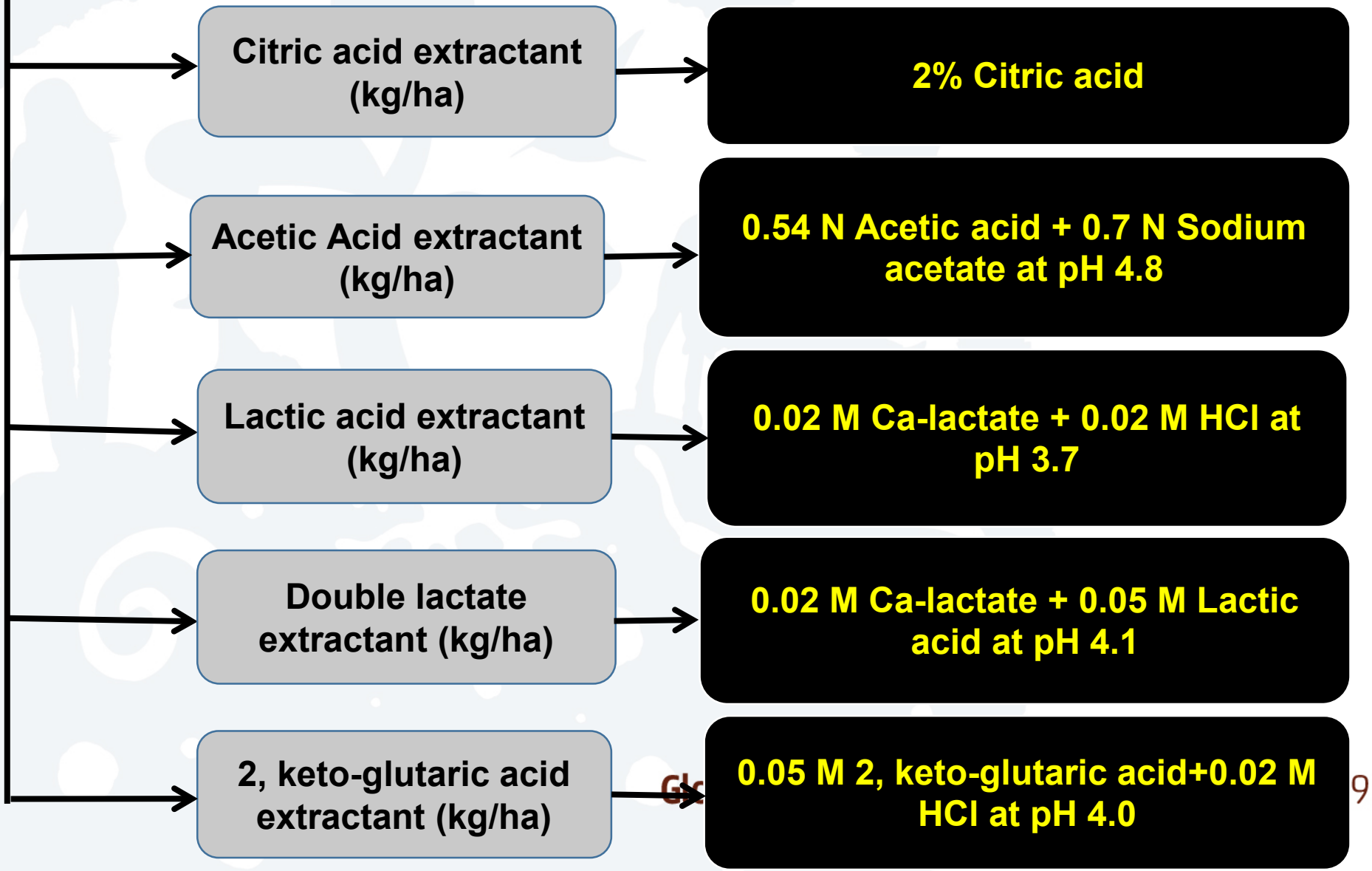
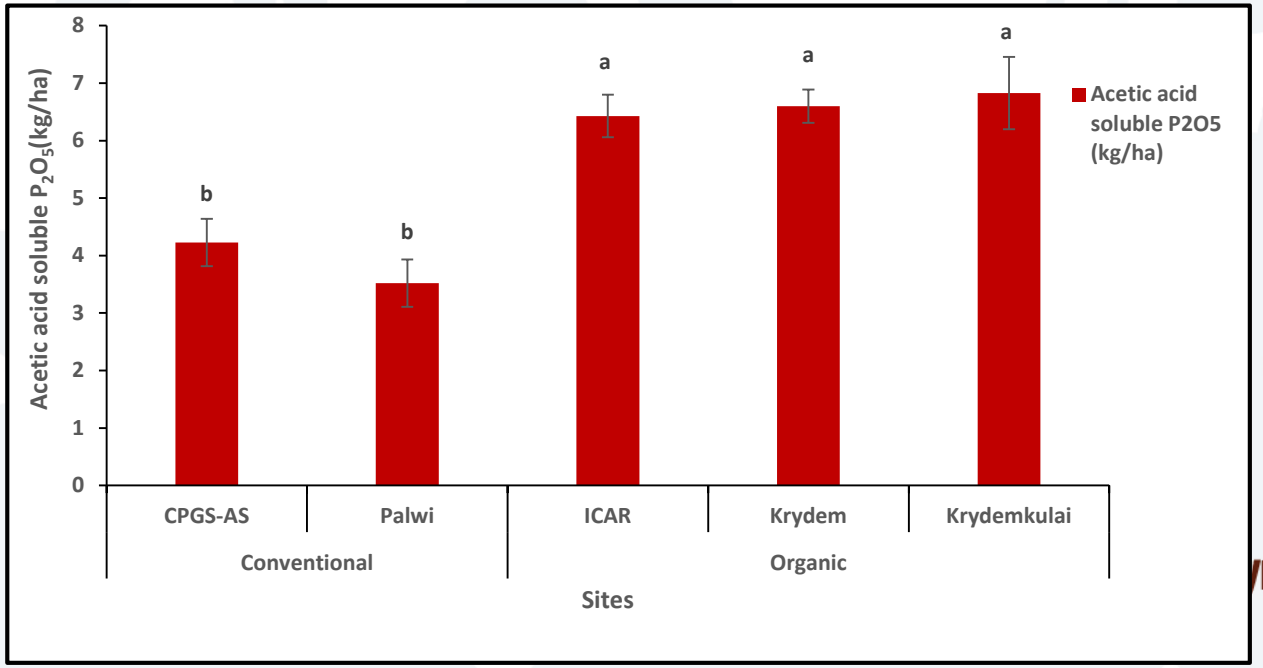
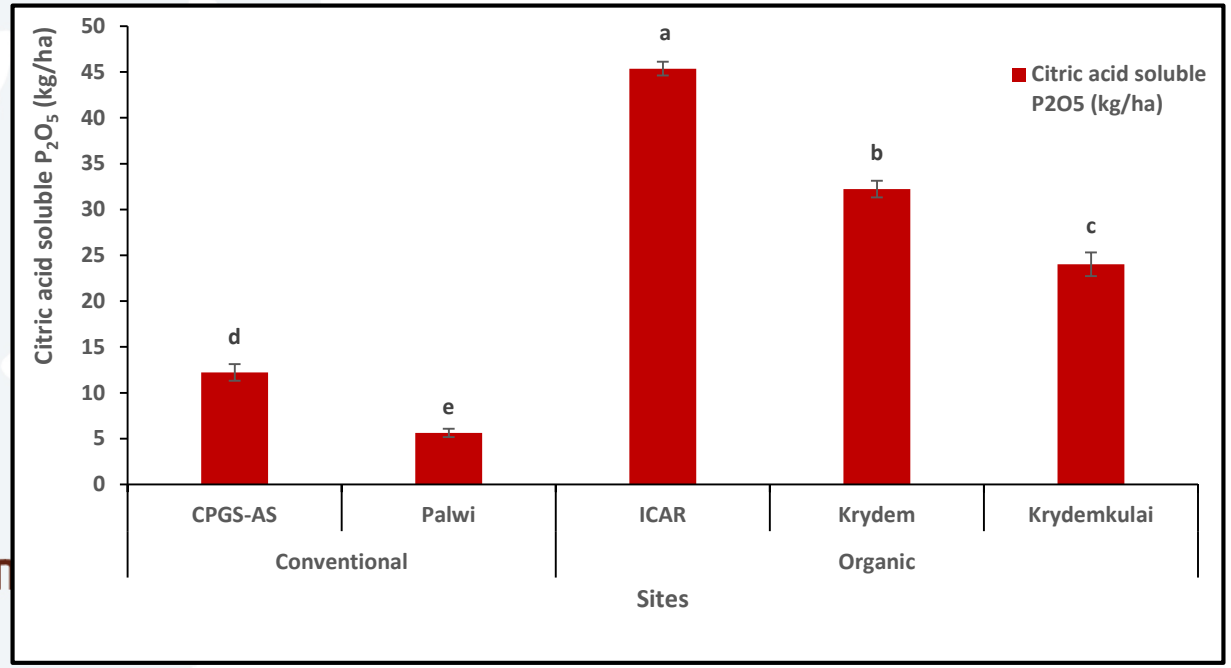


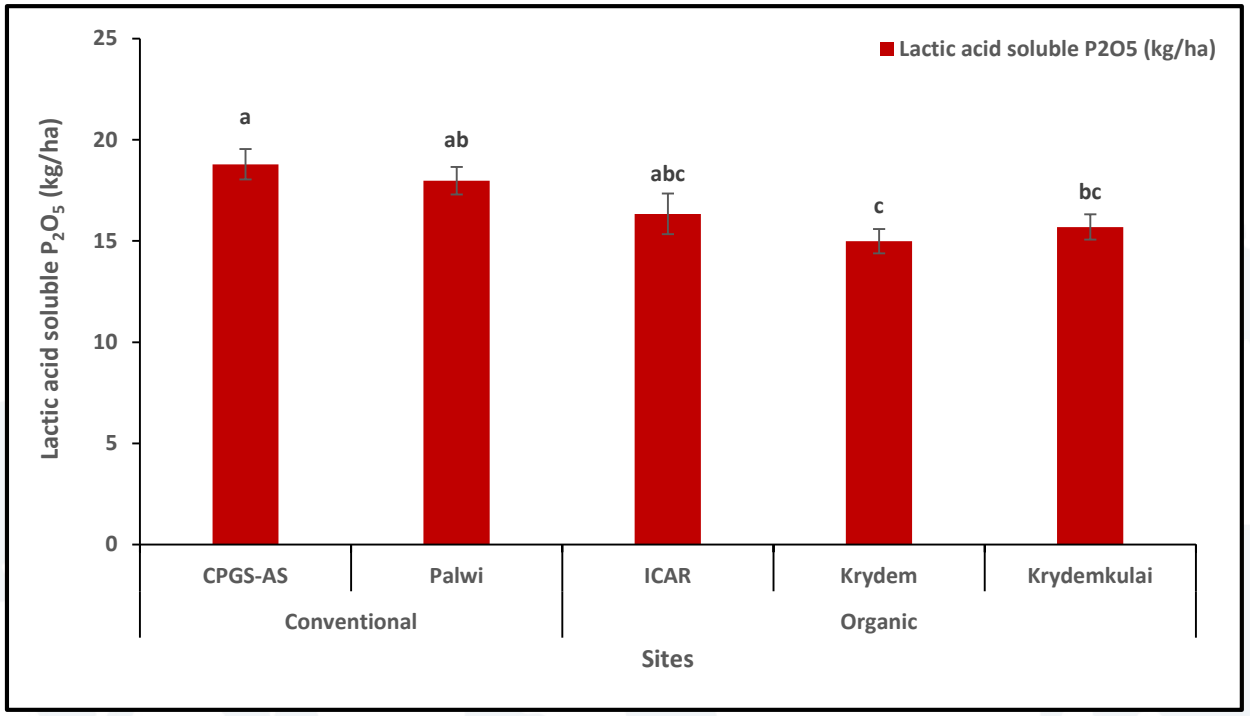
Table 2: Results of Acetic acid, citric acid, lactic acid, double lactate and 2, ketoglutaric acid soluble P_2O_5 of different sites

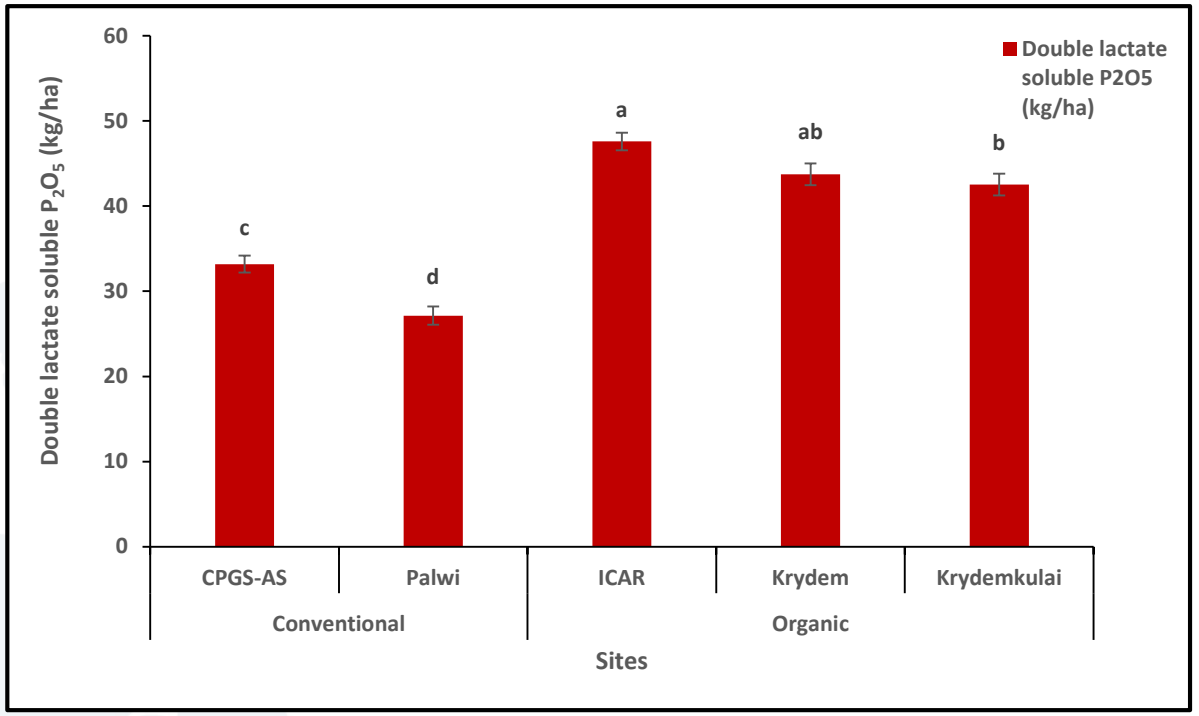
Site	Status	Acetic acid soluble P_2O_5 (kg/ha)	Citric acid soluble P_2O_5 (kg/ha)	Lactic acid soluble P_2O_5 (kg/ha)	Double lactate soluble P_2O_5 (kg/ha)	2, ketoglutaric acid soluble P_2O_5 (kg/ha)
CPGS-AS	Conventional	4.227±0.41b	12.220±0.90d	18.790±0.75a	33.180±1.00c	29.631±1.06c
Palwi	Conventional	3.520±0.41b	5.630±0.46e	17.983±0.68ab	27.137±1.06d	25.257±1.00c
ICAR	Organic	6.427±0.37a	45.365±0.75a	16.340±1.00abc	47.590±1.03a	60.413±1.06b
Krydem	Organic	6.599±0.29a	32.231±0.90b	14.990±0.60c	43.736±1.29ab	63.344±1.49ab
Krydemkulai	Organic	6.827±0.63a	24.027±1.28c	15.693±0.62bc	42.517±1.28b	68.120±1.71a

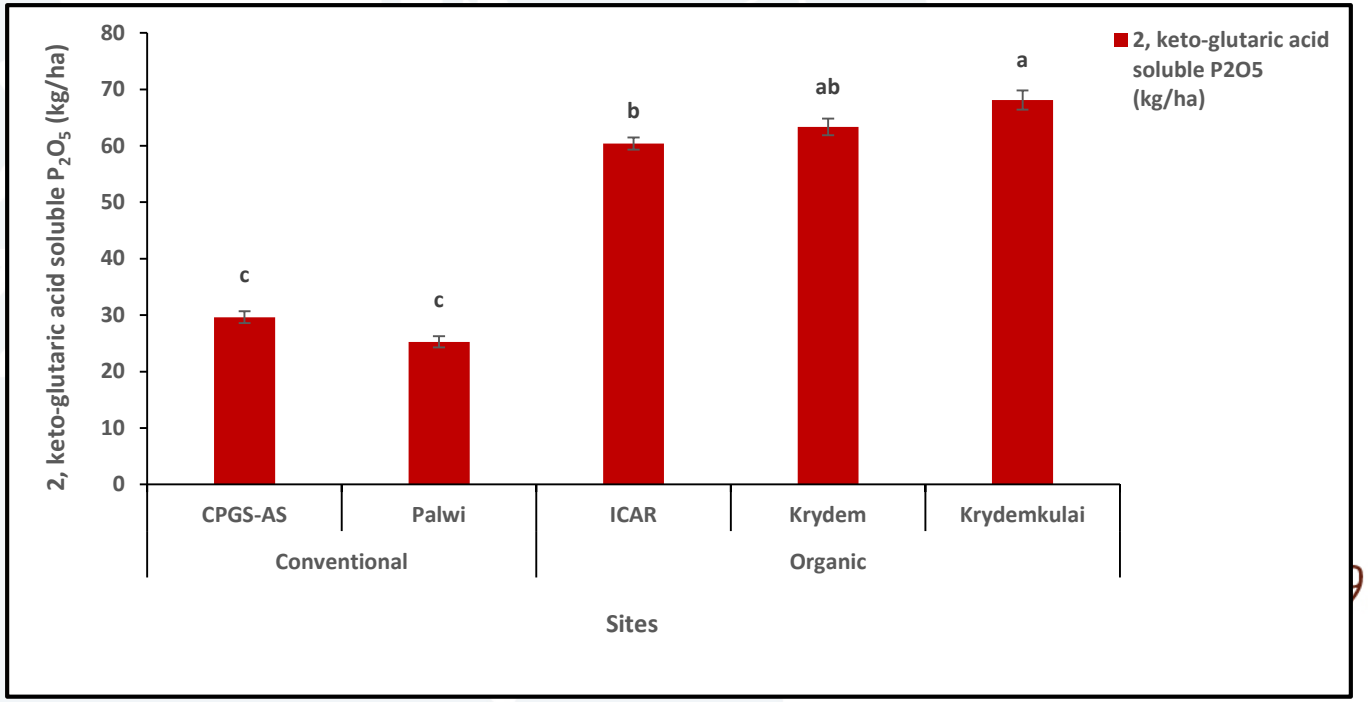
*Means not sharing the same letters in the same column differs significantly (at p<0.01) by DMRT






Lactic acid soluble P2O5 (kg/ha)
Lactic acid soluble P_2O_5 (kg/ha)
25
20
15
10
5
0
a
ab
abc
c
bc
CPGS-AS
Palwi
ICAR
Krydem
Krydemkulai
Conventional
Organic
Sites


Double lactate soluble P2O5 (kg/ha)
Double lactate soluble P_2O_5 (kg/ha)
60
50
40
30
20
10
0
c
d
a
ab
b
CPGS-AS
Palwi
ICAR
Krydem
Krydemkulai
Conventional
Organic
Sites


2, keto-glutaric acid soluble P2O5 (kg/ha)
2, keto-glutaric acid soluble P_2O_5 (kg/ha)
80
70
60
50
40
30
20
10
0
c
c
b
ab
a
CPGS-AS
Palwi
ICAR
Krydem
Krydemkulai
Conventional
Organic
Sites

Regression analysis

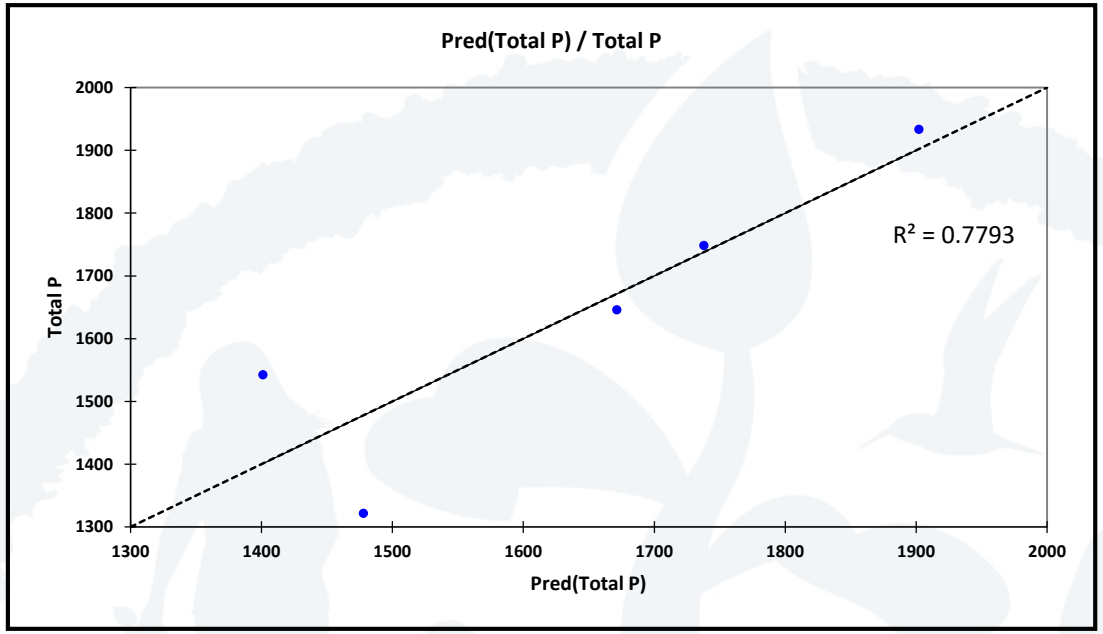
- Total P, organic carbon and Bray-1 P (check).
- Total P, organic carbon and citric acid-P.
- Total P, organic carbon and acetic acid-P.
- Total P, organic carbon and lactic acid-P.
- Total P, organic carbon and double lactate-P.
- Total P, organic carbon and 2, keto-glutaric acid-P.

- Total P, organic carbon, citric acid-P and acetic acid-P.
- Total P, organic carbon, citric acid-P and lactic acid-P.
- Total P, organic carbon, citric acid-P and double lactate-P.
- Total P, organic carbon, citric acid-P and 2, keto-glutaric acid-P.
- Total P, organic carbon, acetic acid-P and lactic acid-P.
- Total P, organic carbon, acetic acid-P and double lactate-P.
- Total P, organic carbon, acetic acid-P and 2, keto-glutaric acid-P.
- Total P, organic carbon, lactic acid-P and double lactate-P.
- Total P, organic carbon, lactic acid-P and 2, keto-glutaric acid-P.
- Total P, organic carbon, double lactate-P and 2, keto-glutaric acid-P.

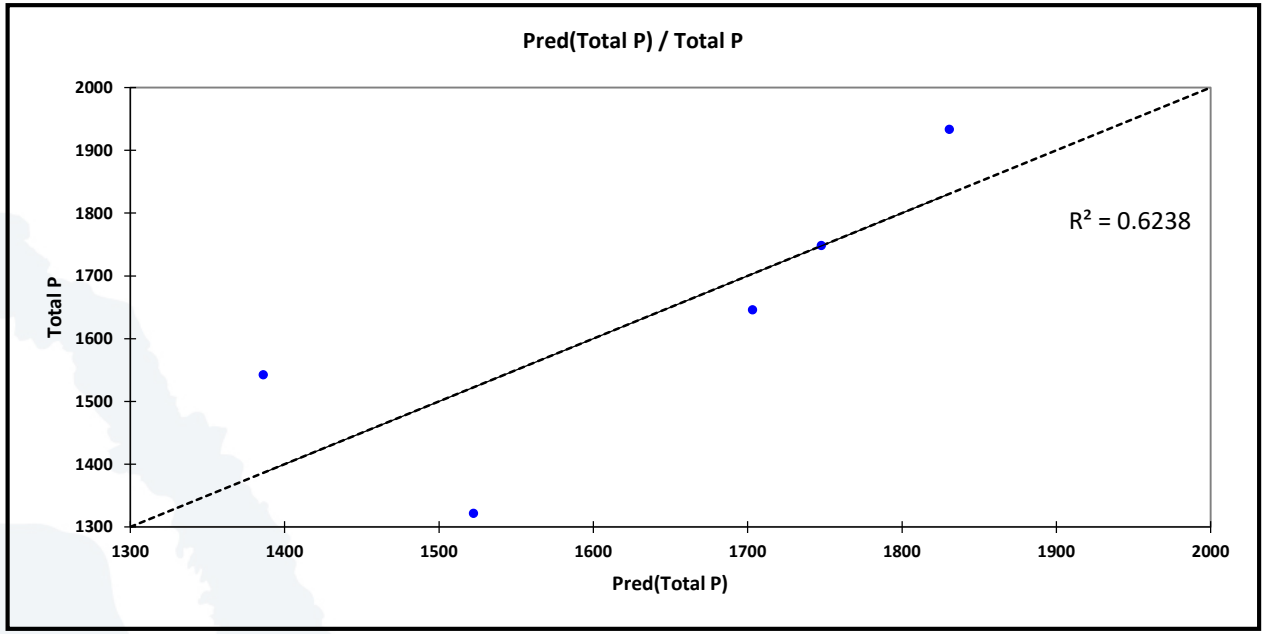
✓ Strong relationship: Better Extractant.

Table 7: Regression equations/relations of total P (kg/ha), organic carbon(%) and extractants soluble P (kg/ha)

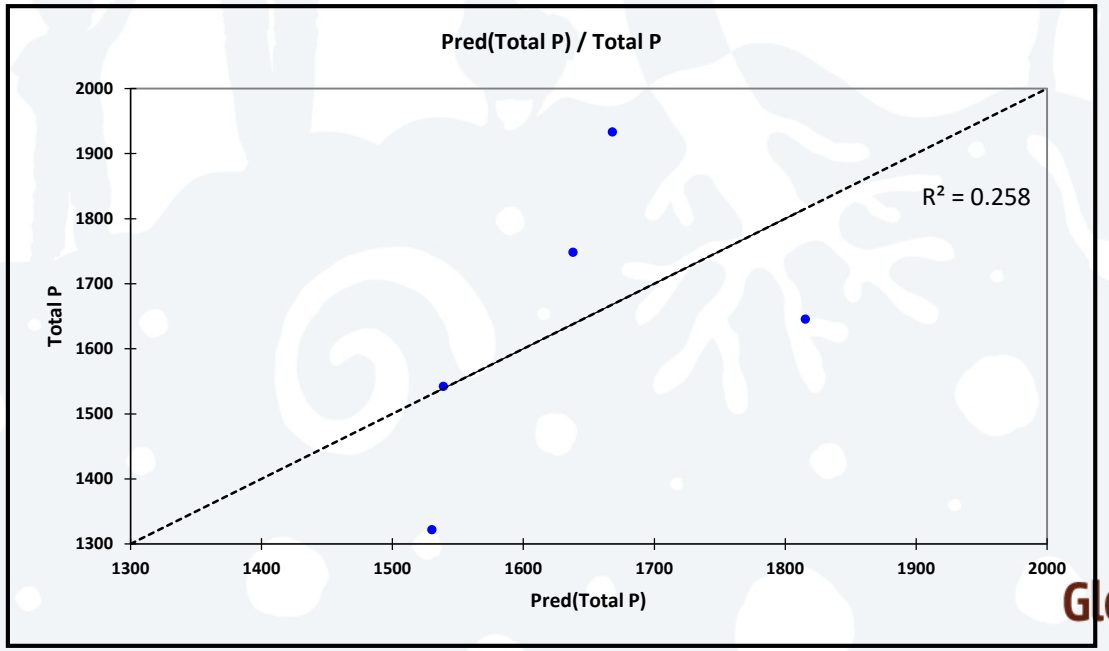
Sl. No.	Equation	R^2
1	Total P= 1289.18 + 36.77 OC% + 12.05 (Citric acid-P)	0.78
2	Total P= 804.18 – 19.70 OC% + 22.32 (Double lactate-P)	0.62
3	Total P= 1283.70 + 203.10 OC% + 1 (Bray-1 P)	0.26
4	Total P= 2566.36 + 268.41 OC% + 37.75 (Citric acid-P) – 58.63 (Double lactate-P)	0.93


Pred(Total P) / Total P
Total P
Pred(Total P)
R² = 0.7793
2000
1900
1800
1700
1600
1500
1400
1300
1300
1400
1500
1600
1700
1800
1900
2000

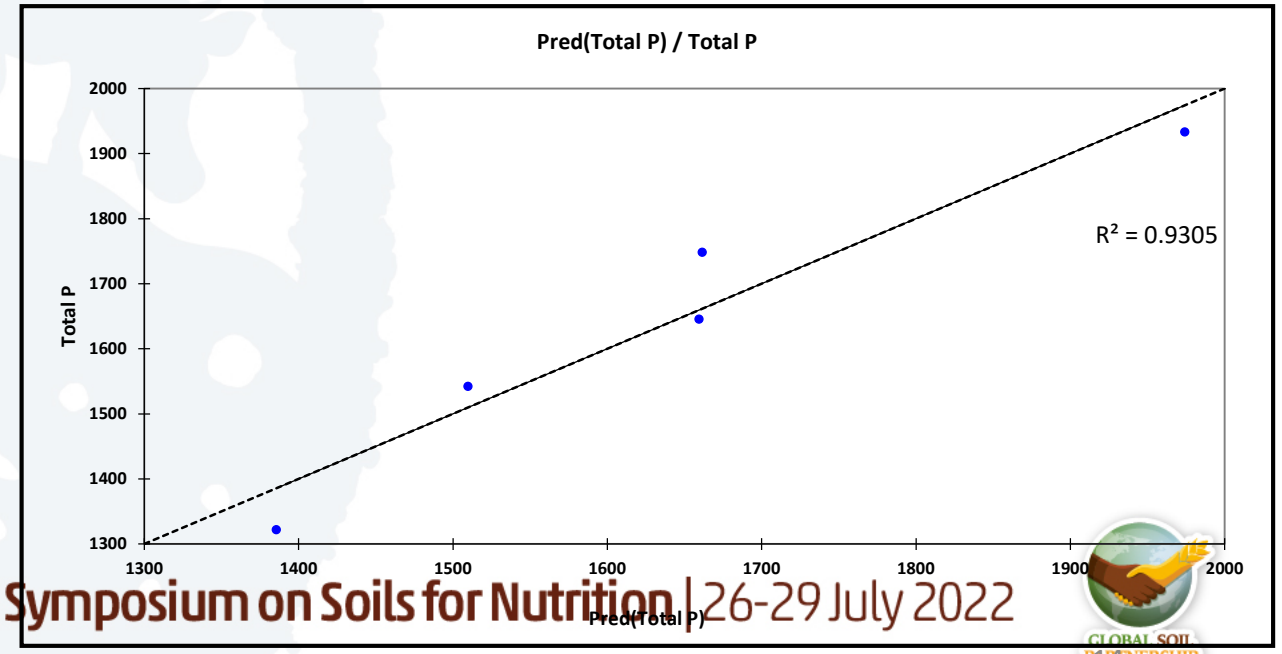
1


Pred(Total P) / Total P
Total P
Pred(Total P)
R² = 0.6238
2000
1900
1800
1700
1600
1500
1400
1300
1300
1400
1500
1600
1700
1800
1900
2000

2


Pred(Total P) / Total P
Total P
Pred(Total P)
R² = 0.258
2000
1900
1800
1700
1600
1500
1400
1300
1300
1400
1500
1600
1700
1800
1900
2000

3


Pred(Total P) / Total P
Total P
Pred(Total P)
R² = 0.9305
2000
1900
1800
1700
1600
1500
1400
1300
1300
1400
1500
1600
1700
1800
1900
2000

4

Conclusion:

- The highest R^2 value i.e., 0.93 for citric acid and double lactate extractant defines the highest variation of total P in an organic production system.

Hence,

- It is advised to use citric acid and double lactate extractants for P estimation in acidic soils of Ri-Bhoi district under organic production and accordingly suggest P doses through organic sources.


Thank you !
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