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# RELATIVE EFFICIENCY OF DIFFERENT EXTRACTANTS FOR DETERMINATION OF AVAILABLE PHOSPHORUS IN THE PUNJAB SOILS

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**Abstract.** Studies were carried out to determine the relative P-extracting efficiency of Bray I, $NaHCO_3$and $H_2O$ at different soils in the Punjab. It was observed that the P-values estimated through Bray I method were invariably high and were followed by values as 0.5M $NaHCO_3$ and $H_2O$ at all locations. The correlation coefficients of 0.83 and 0.75 were found respectively for Bray I-P and $H_2O$-P with $NaHCO_3$. The regression equations for estimated values were:

P-Bray I = 1.78 P-$NaHCO_3$—2.08
P-$H_2O$ = 0.79 P-$NaHCO_3$—0.68

The soil–plant relation studies also showed insignificant differences between calculated and actual yields with these extractants.

The findings thus proved that the efficiency of these extractants for soil P estimation and their interchangeable use with the considerable degree of reliability.

The monoestimation techniques for different food elements are costly and time-consuming if adopted individually. These limitations are seriously felt with the introduction of Soil Advisory Service in the country. To provide information in time to the growers it is imperative to devise rapid, efficient and economical flow-type technique through adoption of multiuse extractants in the soil testing laboratories.

A large number of extractants are in vogue for the estimation of available P in different soils. Of these 0.03N $NH_4F$+0.025N HCl[1,4] 0.5M $NaHCO_3$ at 8.5 pH and distilled water [2,9,13] are widely adopted in calcareous soils. The suitability of these extrac tants was adjusted on physicographic basis and evaluated by many workers [3,7,9–12] as these extractants gave the highest correlations between soil tests and crop response.

The purpose of this study is to determine the relative extracting capacities of Bray-I solution (0.03N $NH_4F$+0.025N HCl), sodium bicarbonate (0.5M 8.5 pH) and distilled water[14] for available P in soils and make available this information for decision concerning the selection of multiuse extractants.

## Materials and Methods

The soil samples (355) were collected from the sites of Soil Plant Realtionship Experiments on Phosphorus conducted at Agricultural Farms, Lyallpur, Chuharkana (Shaikhupura), Gujranwala, Sahiwal, Sargodha, Mianwali and Multan in order to cover all possibile variations in the Punjab soils. From the selected sites, 6-in sufrace soil samples were taken through standard technique.[6] The samples were air-dried, ground, passed through 2 mm sieve and then stroed in plastic bottles for analysis.

The soil extractans were used and the available phosphorus thus extracted was determined colorimetrically. The data both in field and laboratory were reported on air-dried basis.

These analysis of variance, correlation coefficients and regression equations were used for the statistical expression of results. For correlation with the field response the Modified Mitscherlich's equation[1] was used, i.e.

$$\log (A-Y) = \log A - C_1 b - C \log x$$

The yield were calculated for each extractant and compared with the yield obtained in the field through application of t-test for significance.

## Results and Discussion

*Soil and its Characteristics.* The perusal of physicochemical characteristics of soil (Table 1) reveals that the texture in general varied from light i.e. sandy loam, loamy sand (Lyallpur 2, 3; Mianwali 1) and silt loam (Lyallpur 1, Sheikhupura 1 and Sargodha 1) to medium i.e. loam (Shaikhupura 2, Gujranwala 1, Sahiwal 2, Sargodha 2 and Multan 1), loam to silt loam (Sahiwal 1) and medium to heavy i.e. loam to clay loam (Gujranwala 2). All the sites were free from salinity hazard and invariably had low organic matter and available phosphorus.[10] The soil pH varied from 7.6 to 8.4.

*Comparison of Methods.* The values obtained as water soluble-P were lower than those estimated as 0.5M $NaHCO_3$ and Bray-I methods at all locations (Table 2) Bray-I method yielded higher P-values and was followed by $NaHCO_3$. The analysis of variance (Table 2) reveals that P-estimation efficiency of all extractants with L.S.D. test further indicated that all methods were significantly different from each other. This is in accordance with the previous finding as the amount of available phosphorus extracted from a soil depends upon the nature of extractant.

The estimated P-values of Bray-I and $H_2O$ extracts gave a positive correlation with $NaHCO_3$-P and correlation coefficient were found 0.83 and 0.75 respectivley (Figs. 1, 2). The regression equations were

P-Bray I = 1.78 P-$NaHCO_3$—2.08
P-$H_2O$ = 0.79 P-$NaHCO_3$—0.68

The correlation of Bray I-P and $H_2O$-P with $NaHCO_3$-P showed that both extractants can be

TABLE 1. AVERAGE PHYSICOCHEMICAL CHARACTERISTICS OF SOIL.

| Station | Site | No. of sample | pH 1:1 | Chemical analysis of soil–water ratio (1:10) | | | | | | Organic matter (%) | Available P (ppm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | T.S.S. (%) | $CO_3$ (me/l) | $HCO_3$ (me/l) | Cl (me/l) | $SO_4$ (me/l) | Ca+Mg (me/l) | | | |
| Lyallpur | 1 | 33 | 7·78 | 0·09 | Nil | 0·64 | 0·28 | 0·09 | 1·96 | 0·65 | 6·08 | Silt loam |
| | 2 | 47 | 8·24 | 0·11 | ,, | 0·59 | 0·31 | 0·17 | 0·95 | 0·63 | 5·60 | Sandy loam |
| | 3 | 33 | 7·84 | 0·13 | ,, | 0·71 | 0·42 | 0·19 | 1·29 | 0·90 | 7·65 | Sandy loam |
| Sheikhupura | 1 | 11 | 7·84 | 0·16 | ,, | 0·84 | 0·38 | 0·55 | 1·11 | 0·94 | 5·68 | Silt loam |
| | 2 | 33 | 7·94 | 0·16 | ,, | 0·83 | 0·56 | 0·40 | 0·98 | 0·97 | 6·34 | Loam |
| Gujranwala | 1 | 11 | 8·41 | 0·12 | ,, | 0·85 | 0·31 | 0·12 | 0·82 | 0·84 | 4·00 | Loam |
| | 2 | 33 | 7·97 | 0·15 | ,, | 0·82 | 0·51 | 0·35 | 0·87 | 0·95 | 4·12 | Loam to clay loam |
| Sahiwal | 1 | 11 | 7·60 | 0·21 | ,, | 0·87 | 0·32 | 1·11 | 1·59 | 0·88 | 5·04 | Loan to silt loam |
| | 2 | 33 | 7·98 | 0·13 | ,, | 0·68 | 0·46 | 0·34 | 1·51 | 0·86 | 4·91 | Loam |
| Sagodha | 1 | 11 | 8·25 | 0·09 | ,, | 0·65 | 0·24 | 0·09 | 1·12 | 0·74 | 3·80 | Silt loam |
| | 2 | 33 | 7·78 | 0·10 | ,, | 0·48 | 0·34 | 0·36 | 1·95 | 0·89 | 4·21 | Loam |
| Mianwali | 1 | 33 | 8·08 | 0·08 | ,, | 0·52 | 0·25 | 0·19 | 0·98 | 0·34 | 4·39 | Sandy loam to loamy sand |
| Multan | 1 | 33 | 7·60 | 0·09 | ,, | 0·63 | 0·28 | 0·16 | 1·32 | 0·84 | 4·20 | Loam |

TABLE 2. MEAN VALUES OF AVAILABLE PHOSPHORUS FOR DIFFERENT EXTRACTS.

| Methods | Stations | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lyallpur | | | Sheikhupura | | Gujranwala | | Sahiwal | | Sargodha | | Mianwali | Multan |
| | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 3 | 1 | 2 |
| Bray I–soluble P | 10·84[a] | 8·06[a] | 11·99[a] | 6·93[a] | 7·45[a] | 4·81[a] | 5·16[a] | 6·24[a] | 5·89[a] | 4·83[a] | 5·47[a] | 7·52[a] | 5·27[a] |
| $NaHCO_3$–soluble P | 6·08[b] | 5·60[b] | 7·65[b] | 5·68[b] | 6·34[b] | 4·00[b] | 4·12[a] | 5·04[b] | 4·91[b] | 3·80[b] | 4·21[b] | 4·39[b] | 4·20[b] |
| Water–soluble P | 4·19[b] | 3·80[c] | 5·40[c] | 3·25[c] | 4·87[c] | 2·14[c] | 1·76[b] | 3·18[c] | 4·03[c] | 2·45[c] | 2·99[c] | 2·55[c] | 3·03[b] |
| *Analysis of Variance (F.R. Values)* | | | | | | | | | | | | | |
| Samples | 2·80 | 5·86 | 3·81 | 4·13 | 39·60 | 7·78 | 6·46 | 4·78 | 6·59 | 4·48 | 10·25 | 5·17 | 19·97 |
| Methods | 586·43 | 147·0 | 70·38 | 66·32 | 122·75 | 67·11 | 113·89 | 55·63 | 106·07 | 40·30 | 186·92 | 63·47 | 118·80 |

Note, Mean values followed by the same letter did not differ statistically at 1% level of significance. [a,b,c] Significant difference among treatments.

TABLE 3. WHEAT YIELDS OBTAINED AND CALCULATED.*

| Station | Treatments (lb/acre) $N$-$P_2O_5$ $K_2O$ | Actual yield maunds/acre | Calcd yield maunds/acre | | |
|---|---|---|---|---|---|
| | | | Bray–P | $NaHCO_3$–P | Water–soluble P |
| Lyallpur | 180–30–90 | 42·37 | 45·26 | 45·01 | 44·77 |
| | 180–60–90 | 44·25 | 45·35 | 45·30 | 45·28 |
| | 180–90–90 | 45·88 | 45·40 | 45·47 | 45·57 |
| | 180–120–90 | 46·05 | 45·44 | 45·59 | 45·78 |
| | 180–150–90 | 46·74 | 45·46 | 45·68 | 45·94 |
| | 180–180–90 | 47·51 | 45·49 | 45·75 | 46·07 |
| | 180–210–90 | 46·57 | 45·51 | 45·81 | 46·18 |
| | 180–240–90 | 47·25 | 45·52 | 45·87 | 46·28 |
| Sheikhupura | 180–30–90 | 41·72 | 45·22 | 45·18 | 44·68 |
| | 180–60–90 | 42·00 | 45·44 | 45·50 | 45·39 |
| | 180–90–90 | 44·52 | 45·58 | 45·69 | 45·80 |
| | 180–120–90 | 45·92 | 45·67 | 45·82 | 46·10 |
| | 180–150–90 | 45·08 | 45·74 | 45·97 | 46·32 |
| | 180–180–90 | 50·40 | 45·80 | 46·00 | 46·50 |
| | 180–210–90 | 49·69 | 45·85 | 46·07 | 46·66 |
| | 180–240–90 | 49·56 | 45·89 | 46·13 | 46·79 |
| Gujranwala | 180–30–90 | 32·21 | 34·48 | 34·35 | 33·67 |
| | 180–60–90 | 32·78 | 34·81 | 34·78 | 34·56 |
| | 180–90–90 | 33·42 | 35·00 | 35·02 | 35·17 |
| | 180–120–90 | 38·93 | 35·12 | 35·19 | 35·53 |
| | 180–150–90 | 40·04 | 35·22 | 35·32 | 35·80 |
| | 180–180–90 | 37·85 | 35·31 | 35·43 | 36·03 |
| | 180–210–90 | 37·96 | 35·38 | 35·22 | 36·22 |
| | 180–240–90 | 36·92 | 35·44 | 35·60 | 36·38 |
| Sahiwal | 180–30–90 | 36·96 | 40·23 | 40·61 | 40·25 |
| | 189–60–90 | 37·96 | 40·38 | 40·97 | 40·91 |
| | 180–90–90 | 38·39 | 40·62 | 41·16 | 41·30 |
| | 180–120–90 | 48·44 | 40·72 | 41·31 | 41·56 |
| | 180–150–90 | 47·60 | 40·80 | 41·42 | 41·77 |
| | 180–180–90 | 40·88 | 40·86 | 41·51 | 41·95 |
| | 189–210–90 | 40·60 | 40·91 | 41·59 | 42·07 |
| | 180–240–90 | 44·80 | 40·96 | 41·65 | 42·21 |
| Sargodha | 180–30–90 | 49·84 | 48·09 | 47·88 | 47·46 |
| | 180–60–90 | 47·68 | 48·53 | 48·52 | 48·59 |
| | 180–90–90 | 53·34 | 48·79 | 48·89 | 49·15 |
| | 180–120–90 | 49·00 | 48·97 | 49·14 | 49·59 |
| | 180–150–90 | 44·52 | 49·11 | 49·33 | 49·92 |
| | 180–180–90 | 48·16 | 49·23 | 49·49 | 50·20 |
| | 180–210–90 | 48·60 | 49·32 | 49·63 | 50·46 |
| | 180–240–90 | 53·76 | 49·40 | 49·75 | 50·63 |

tBray–I–soluble P = 0·63 N.S.
t$NaHCO_3$–soluble P = 0·47 N.S.
tWater–soluble P = 0·23 N.S.

*Wheat yield for three extractants calculated with the help of modified Mitscherlich equation.

adopted in place of $NaHCO_3$ for the estimation of soil-P. The results are in agreement with previous findings of Olsen *et al.*[8,10] and Bingham.[2]

*Soil Test—Crop Response Studies.* Correlation Studies of Soil Test Values: The yield of wheat were made on the data from soil–plant relationship experiments conducted at Lyallpur, Chunharkana (Sheikhupura), Gujranwala, Sahiwal and Sargodha. The rate of fertilizer-P, obtained and the calculated yields with different extractans are presented in Table 3.

The constants for soil test value ($C_1$ – regression coefficient) and added fertilizer-P ($C$ – efficiency of fertilizer) were used for the extractans with the Modified Mitscherlich equation. These values were calculated by Malik and Hanif,[8] and are shown below:

$C_1$ – value = 0.0919
$C$ – value = 0.0280

The two constants $C_1$ for $b$ and $C$ for $\log x$, were used to recalculate the values of $Y$ (calcd yields) through using A-value. The calculated values for different fertilizer rates were almost equal for these extractants. Similarly, the comparison of calculated and obtained yields by the application of t-test gave a nonsignificant difference between the two values, meaning thereby that the extracting efficiency of all these extractants was almost similar. This test further confirmed the validity of the extractants and their interchangeable use for fertilizer recommendation based on soil test values with considerable degree of reliability.

*Summary.* The studies were carried out to determine the relative P-extracting efficiency of three extractants viz. Bray I, $NaCHO_3$ and $H_2O$ at 13 different locations. The sample location covered almost all possible variations in the Punjab soils.

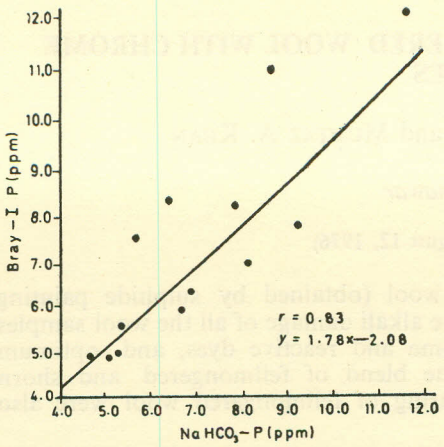


Fig. 1 Correlation coefficient–Bray–P and $NaHCO_3$–P.

The analysis of variance, correlation coefficient and regression equations were manipulated on the data for P-estimation in soil with these extractans. The validity of soil test values in the field was tested through modified Mitscherlich equation and yields thus obtained were subjected to t-test for significance.

It was observed that magnitude of $H_2O$-P was lower than other two methods, i.e. Bray I and $NaHCO_3$. The correlation studies showed that the P-values of Bray I and $H_2O$ were highly correlated to $NaHCO_3$-P and correlation coefficients were found to be 0.83 and 0.75 respectively. The regression equations for estimated values were:

$$\text{P-Bray I} = 1.78\ \text{P-NaHCO}_3 - 2.08$$
$$\text{P-H}_2\text{O} = 0.79\ \text{P-NaHCO}_3 - 0.68$$

The relationship of soil–test values and field response to added P showed insignificant differences between the calculated values for the three different extractants and wheat yield, obtained and calculated for different rates at various locations.

The studies thus proved that the efficiency of all the three extractants for soil-P estimation and their interchangeable use with considerable degree of reliability. The soil test values are also valid in apprising the response to added P in the field.

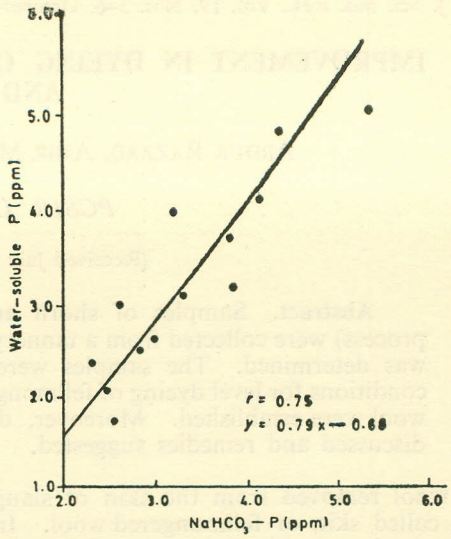


Fig. 2. Correlation coefficient—water-soluble-P and $NaHCO_3$-P.

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