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# Evaluation of Phosphorus Status of Thrace Region Soils and Suitability of Different Chemical Methods Used to Determine Plant Available Soil Phosphorus of These Soils

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## Abstract

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The purpose of this research is to determine the phosphorus amount of soils of Tekirdag province that have different chemical and physical properties according to the Neubauer method which is selected as a biological method and to select the method which gives highest relationship from the 3 different chemical extraction methods for determining the available phosphorus amount. For this purpose 26 samples of soil are collected from 0-20 cm's depth in Tekirdag.

The greenhouse study has been performed in accordance to the Neubauer seedling method and coincidence pattern with 3 repetitions. The rye (*Secale cerale* L.) has been selected as the test plant.

In order to determine the most suitable chemical method as related to dried matter yield, phosphorus content and total phosphorus uptake of the test plant has been taken as the biological (standard) criterion.

No relationship has been found between any of the chemical extraction methods and dry matter yield of rye plant in this study.

According to the research results, significant relationships have been found only with the water soluble phosphorus method and phosphorus content and total phosphorus uptake of the test plant (respectively r= 0.374*, r= 0.342*).

*Key words*: Neubauer method, rye, phosphorus, extraction method

## Introduction

One of the lacking plant nutrients for the soils of our country is phosphorus, which is to be added by fertilizing. In addition, phosphorus is an essential nutrient for living creatures. There is no element as important as phosphorus for the plants except nitrogen. It is known that phosphorus, which is found in all living cells, has a great role in photosynthesis, in synthesis and analysis of carbohydrates and in energy transportation inside the cell. The phosphorus which is mostly occurred in young portions such as flowers and seeds is utilized for new cell formation (Yurtsever, 1973).

The factors such as clay type and amount, organic material content, Fe, Al, $CaCO_3$ and pH levels affect the phosphorus suitability and holding. For that reason, information about the phosphorus behavior in soils leads the way in using the phosphorus fertilizers (Velayutham, 1980).

It is now inevitable to increase the possibility to take the highest crop from unit area because of the problems about the depletion of agricultural areas, the continuous reduction in rural population, the increasing world population, the famine and inadequate nourishment in under developed and developing countries. For that reason, alongside the irrigation, mechanization, good seedling, insecticidizing and farmer education factors, the fertilizer usage is also very important. Fertilizers are one of the most important production inputs which increase the agricultural efficiency (Yilmaz, 2004).

Thrace is a region where the soil is used effectively. %20 of the fertilizers consumed in Turkey is used in this region. Most of the phosphorus fertilizers used in Marmara Agricultural Region between 1972 and 2000 have been consumed in Tekirdag county (22 246 ton $P_2O_5$/year) (Eyupoglu, 2002).

In a research performed in Tekirdag county with 20 soils it has been determined that %45 of the soils contain excessive phosphate (Belliturk and Saglam, 2005).

Neubauer has made a study for determining the seedling method and the method, which gives the highest relationship with 9 different chemical extraction methods in determining the beneficial phosphorus amount of Erzurum-Daphan plain soils. At this mentioned study, none of the chemical extraction methods related with the biological methods (Yildiz et al., 2003).

In this study, it is aimed to select the most proper method for determining the suitable phosphate amount in wheat and sunflower cultivated Tekirdag soils.

## Material and Method

The research has performed in 26 soil samples which show different textures and taken from 0-20 cm depth of various locations in Tekirdag before the cultivation and fertilization in 2004-2005 wheat and sunflower season (Kacar, 1995). The physical and chemical analyses of the soils have been made at the Thrace University Tekirdag Agriculture Faculty Soil Department laboratories. The pH, salinity, organic material, limes and texture analyses (Saglam, 2001) have been made in soil samples (Tuzuner, 1990). MSTAT computer software has been used in statistical analysis of data obtained in trial.

### *Methods Used to Determine the Available Soil Phosphorus*

**Biological method:** Neubauer Method has been used as a biological method for

**Table 1**

**Some physical and chemical properties of soil samples**

| Soil No | pH (1/2.5 $H_2O$) | Salt, % | Organic Matter, % | $CaCO_3$, % | Structure | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Clay, % | Silt, % | Sand, % | Class |
| 1 | 6.5 | 0.01 | 1.16 | 0 | 27.53 | 39.63 | 32.83 | CL |
| 2 | 6.57 | 0.01 | 1.4 | 0 | 18.09 | 14.33 | 67.58 | SL |
| 3 | 7.43 | 0.02 | 2.16 | 0 | 43.13 | 4.27 | 52.6 | SC |
| 4 | 8.01 | 0.03 | 1.65 | 16.8 | 38.02 | 48.05 | 13.93 | SiCL |
| 5 | 5.4 | 0.01 | 0.95 | 0 | 8.46 | 10.07 | 81.47 | LS |
| 6 | 7.82 | 0.01 | 0.69 | 2 | 32.19 | 4.24 | 63.58 | SCL |
| 7 | 7.98 | 0.02 | 2.01 | 9.21 | 21.33 | 52.29 | 26.38 | SiL |
| 8 | 7.96 | 0.01 | 1.73 | 8.8 | 37.52 | 43.29 | 19.19 | SiCL |
| 9 | 6.69 | 0.02 | 1.51 | 0 | 39.41 | 6.16 | 54.43 | SC |
| 10 | 7.98 | 0.04 | 0.99 | 12.41 | 23.14 | 35.13 | 41.73 | L |
| 11 | 6.74 | 0.01 | 1.32 | 0 | 38.26 | 35.73 | 26.01 | CL |
| 12 | 7.82 | 0.03 | 0.98 | 2 | 25.67 | 46.29 | 28.05 | L |
| 13 | 8.2 | 0.02 | 1 | 7.21 | 30.1 | 47.54 | 22.36 | CL |
| 14 | 8.22 | 0.02 | 1.03 | 10 | 37.87 | 34.69 | 27.44 | CL |
| 15 | 6.65 | 0.01 | 1.26 | 0 | 22.41 | 36.94 | 40.65 | L |
| 16 | 7.16 | 0.02 | 1.09 | 0 | 17.44 | 24.45 | 58.1 | SL |
| 17 | 7.56 | 0.03 | 0.41 | 2.97 | 30.9 | 24.25 | 44.85 | CL |
| 18 | 7.58 | 0.03 | 1.77 | 9.48 | 31.53 | 42.47 | 26 | CL |
| 19 | 6.73 | 0.01 | 1.7 | 0.38 | 27.19 | 14.47 | 58.34 | SCL |
| 20 | 7.7 | 0.02 | 1.26 | 1.44 | 34.15 | 34.92 | 29.92 | CL |
| 21 | 7.2 | 0.02 | 2.49 | 0.39 | 29.73 | 39.87 | 30.4 | CL |
| 22 | 7.94 | 0.02 | 1.65 | 5.46 | 34.01 | 37.51 | 28.48 | CL |
| 23 | 7.63 | 0.02 | 0.79 | 14.75 | 9.23 | 28.84 | 61.93 | SL |
| 24 | 7.68 | 0.02 | 1.96 | 1.92 | 25.32 | 18.38 | 56.3 | SCL |
| 25 | 7.38 | 0.02 | 1.01 | 0.19 | 16.5 | 23.54 | 59.96 | SL |
| 26 | 7.3 | 0.01 | 1.41 | 0.38 | 20.78 | 18.04 | 61.18 | SCL |
| Min, | 5.4 | 0.01 | 0.41 | 0 | 8.46 | 4.24 | 13.93 | |
| Max, | 8.22 | 0.04 | 2.49 | 16.8 | 43.13 | 52.29 | 67.58 | |

determining the phosphorus contents of the soil samples in conformity with its rules (Saglam, 2002). That method is widely used as a standard method for calibrating the chemical extraction methods. For the application of Neubauer method, 100 mature rye seeds of which their weights measured are cultivated in glass pots with a

**Table 2**

**Useful phosphorus amounts (ppm) determined with different chemical extraction methods from soil samples**

| Soil No | Chemical Extraction Methods | | |
|---|---|---|---|
| | Water Soluble Phosphorus Method (ppm P) | Soluble Phosphorus Method in Acid Fluoride (ppm P) | Soluble Phosphorus Method in Sodium Bicarbonate (ppm P) |
| 1 | 4.46 | 8.466 | 3.42 |
| 2 | 6.107 | 22.121 | 4.821 |
| 3 | 14.638 | 24.852 | 11.156 |
| 4 | 1.647 | 6.554 | 1.289 |
| 5 | 17.382 | 40.419 | 18.219 |
| 6 | 0.846 | 12.836 | 0.617 |
| 7 | 2.722 | 18.571 | 0.785 |
| 8 | 1.555 | 27.31 | 1.794 |
| 9 | 1.166 | 25.671 | 3.476 |
| 10 | 2.79 | 23.213 | 0.561 |
| 11 | 3.682 | 17.752 | 5.214 |
| 12 | 3.339 | 6.554 | 0.729 |
| 13 | 2.127 | 17.205 | 1.514 |
| 14 | 2.516 | 29.768 | 0.448 |
| 15 | 10.749 | 19.663 | 7.232 |
| 16 | 17.153 | 46.154 | 10.707 |
| 17 | 0.132 | 12.563 | 1.794 |
| 18 | 0.232 | 12.836 | 1.177 |
| 19 | 1.192 | 14.747 | 7.96 |
| 20 | 0.331 | 5.462 | 0.224 |
| 21 | 0.662 | 37.415 | 2.298 |
| 22 | 0.331 | 10.651 | 2.242 |
| 23 | 0.629 | 12.836 | 0.617 |
| 24 | 0.497 | 21.575 | 0.448 |
| 25 | 2.319 | 32.499 | 14.463 |
| 26 | 0.596 | 35.777 | 3.756 |
| Min, | 0.132 | 5.462 | 0.224 |
| Max, | 17.382 | 46.154 | 18.219 |

mix of 100 g soil and 300 g sand. In parallel with this, rye seeds with the same weight are left for breeding in pots containing 400 g sand. Approximately after 18 days

growth, the root and topsoil organs of plant are processed to chemical analysis and their phosphorus contents are determined. The difference between the contents of plants cultivated in soil and plants cultivated in sand gives the phosphorus amount taken by the plant from the soil. Then, the decision about the soil's fertilizer necessity is reached by considering the phosphorus amount taken by the plant from the soil (Saglam, 2002).

The phosphorus in rye plant was determined with the vanadomolybdophosphoric yellow color method after burnt nitric-perchloric acid mixture (Kacar, 1972).

**Chemical Extraction Methods:** Three different methods have been used for determining the phosphorus amount in soils (Kacar, 1995; Bayrakli, 1986; Saglam, 2001). These methods were summarized briefly below and detailed in Table 1.

**Water Soluble P Method (Bingham method):** Air dried 5 g soil sample are filtered after vibrated 5 min with 50 ml pure water. In this method which is developed by Bingham (1962), the phosphorus transferred to water that treated as extract solution is measured by molybdophosphoric blue color method.

**Acid-Fluoride Soluble P Method (Bray and Kurtz No.1 Method):** Air dried 1 g soil sample are filtered after vibrated 1 min with 7 ml extract solution (0.03 N $NH_4F$+0.025 N HCl). In this method which is developed by Bray and Kurtz (1945), the phosphorus migrated to water that treated as extract solution are measured colorimetrically by molybdophosphoric blue color method.

**Sodium Bicarbonate Soluble P Method (Olsen Method):** Air dried 5 g soil sample are filtered after vibrated 30 min with 100 ml 8.5 pH extract solution (0.5 M $NaHCO_3$). In this method which is developed by Olsen et al. (1954), the phosphorus amount dissolved to water that treated as extract solution are measured by molybdophosphoric blue color method.

## Results and Discussion

***Some Physical and Chemical Properties of Soil Samples*:** Some Physical and Chemical Properties of the studied soils were given in Table 1. The pH values of soil samples vary from 5.40 to 8.22. Considering the percentage salinity values of soil samples, all of them are in salt-free (percentage salt = 0.00-0.15) class (U.S. Soil Survey Staff, 1951). The percentage $CaCO_3$ of the soil samples varies from percentage 0.00 to percentage 16.80. The organic material contents of soils vary from percentage 0.41 to % 2.49. Though organic material content of 6 soils are < % 1.0 these are classified as "very low", organic material content of 17 soils vary % 1.0-2.0 these are classified as "low" and organic material content of 3 soils vary % 2.0-3.0 these are classified as "middle" (Eyupoglu, 1999). According to these results, approx. %90 of soils are lack of organic material. Similar results have been confirmed with the studies made by Belliturk and Saglam (2005). When the texture classes of soils were examined, it seems that they range widely.

***Results Obtained from Chemical Extraction Method:*** The phosphorus amounts of Tekirdag soils found using various chemical extraction methods were given in Table 2. When Table 2 examined,

**Table 3**
**Biological criteria of rye plant according to Neubauer Method**

| Soil No | Dried Matter Yield, g/pot | Phosphorus Content in Plant, % | Phosphorus Uptake by Plant, mg/pot |
|---|---|---|---|
| 1 | 4.02 | 2.67 | 107.3 |
| 2 | 3.95 | 2.63 | 103.9 |
| 3 | 4.45 | 2.45 | 109 |
| 4 | 3.85 | 2.39 | 92 |
| 5 | 3.99 | 2.86 | 114.1 |
| 6 | 4.05 | 2.32 | 93.9 |
| 7 | 3.78 | 2.75 | 104 |
| 8 | 4.36 | 2.57 | 112.1 |
| 9 | 3.95 | 2.42 | 95.6 |
| 10 | 4.25 | 1.68 | 71.4 |
| 11 | 4.4 | 2.5 | 110 |
| 12 | 4.14 | 2.71 | 112.2 |
| 13 | 3.95 | 2.51 | 99.2 |
| 14 | 3.92 | 2.39 | 93.7 |
| 15 | 3.76 | 2.44 | 91.7 |
| 16 | 3.78 | 2.53 | 95.6 |
| 17 | 3.75 | 2.28 | 85.5 |
| 18 | 4.25 | 2.28 | 96.9 |
| 19 | 4.3 | 2.6 | 111.8 |
| 20 | 3.98 | 1.97 | 78.4 |
| 21 | 4.35 | 1.96 | 85.3 |
| 22 | 4.44 | 1.29 | 57.3 |
| 23 | 3.85 | 2.42 | 93.2 |
| 24 | 4.08 | 1.46 | 59.6 |
| 25 | 4.15 | 1.38 | 57.3 |
| 26 | 4.1 | 2.54 | 104 |
| Min, | 3.75 | 0.85 | 57.3 |
| Max, | 4.45 | 2.86 | 114.1 |

it could be seen that the phosphorus amounts determined by the water soluble phosphorus method vary from 0.132 ppm to 17.382 ppm. The lowest value has been got from 17 numbered soils and the highest value from 5 numbered soil. The phosphorus amounts determined by the $NaHCO_3$ soluble phosphorus method vary from 5.462 ppm to 46.154 ppm. The lowest value has been got from 20 numbered soils and the highest value from 16 numbered soil. The phosphorus amounts de-

**Table 4**

**Correlation coefficient of relationships between chemical methods and biological criteria, r**

| Biological Criterion | Chemical Extraction Methods | | |
|---|---|---|---|
| | Water Soluble Phosphorus Method | Soluble Phosphorus Method in Acid Fluoride | Soluble Phosphorus Method in Sodium Bicarbonate |
| Dried matter yield, g/pot | -0.144 # | 0.023 # | 0.069 # |
| Phosphorus content in plant, % | 0.374 * | 0.038 # | 0.130 # |
| Phosphorus uptake by plant, mg/pot | 0.342 * | 0.043 # | 0.156 # |

*: 0.05 significant #: insignificant

termined by the acid-fluoride soluble phosphorus method vary from 0.224 ppm to 18.219 ppm. The lowest value has been got from 20 numbered soils and the highest value from 5 numbered soil.

***Greenhouse Study Results*:**The dry material amounts (g/pot), phosphorus contents (%) and phosphorus intakes (mg/pot) of the rye plant cultivated in Tekirdag soils according to Neubauer method were given in Table 3.

It has been determined that dry material amounts of rye plant cultivated in trial soils according to Neubauer method vary from 3.75 g/pot to 4.45 g/pot, and the phosphorus intakes vary from 57.3 mg/pot to 114.1 mg/pot.

***Relations Between Chemical Methods and Biological Check Values*:** The values belonging to relations between chemical methods and biological check values have been given in Table 4 for choosing the most proper chemical method using for determining the beneficial phosphorus amounts in Tekirdag soils.

As seen in the Table 4, a negative relation (r= -0.144) between dry material amount (g/pot) of rye plant and water-soluble phosphorus method has been determined which is statistically non-significant. Positive relations (r= 0.023 and r=0.069) between dry material amount (g/pot) of rye plant and acid-fluoride soluble phosphorus method has been determined which are also statistically non-significant. In a similar study performed in Erzurum-Daphan plain soils, 9 various chemical extraction methods have been studied and determined that none of these methods are statistically in relation with mentioned standard methods. (Yildiz et al., 2003).

An r= 0.374 positive relation between phosphorus content of rye plant and water soluble phosphorus method has been determined which is statistically significant ($P<0.05$). An r= 0.038 and r=0.130 positive relations between phosphorus content of rye plant and $NaHCO_3$ and water soluble phosphorus methods have been determined which are statistically non-significant.

An r= 0.342 positive relation between phosphorus intake of rye plant and water soluble phosphorus method has been determined which is statistically significant ($P<0.05$). An r= 0.043 and r=0.156 positive relations between phosphorus intake (mg/pot) of rye plant and $NaHCO_3$ and

water soluble phosphorus methods have been determined which are statistically non-significant.

As to Table 4, none of the three chemical extraction methods used in the study about the dry material efficiency of rye plant have given a relation between mentioned standard methods. But, positive relations have been obtained in phosphorus soluble method when P content and P intake biological check values were chosen as criteria.

It has been determined by the researchers who studied on determining the most proper method for Mediterranean region soils and compared various methods that water soluble P method could be applied for the regional soils successfully (Kacar et al., 1976).

## Conclusion

According to research results, appliance of the water-soluble P method could be applied successfully for determining the beneficial P content of regional soils. For obtaining the highest yield from the sustainable agriculture and fertilization, it is vital to determine the phosphorus fertilizer with the proper analysis method.

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