Studying the effect of phosphorus levels on the anion concentration of Maize plants (*Zea mays* L.)

Safa Mahdi AbdulKadium[1]
Soil Sciences and Water Resources Department, College of Agriculture, Al-Qasim Green University, Babylon 51013, Iraq
E-mail: safa@agre.uoqasim.edu.iq

Abstract

During the summer growing season, an agricultural experiment was carried out at the Soil Department, College of Agriculture, Al-Qasim Green University. Zea mays L. seeds were planted in plastic pots using a randomized block design (CRD) and two distinct-textured soils that were extracted from depths ranging from 0 to 30 cm. The first soil (S1) was sourced from the fields of the College of Agriculture and characterized as clay soil, while the second soil (S2) was sourced from the horticulture station and classified as Silty Clay Loam. The experiment aimed to investigate the interplay between phosphate and certain anions on the growth parameters of maize plants. The experimental factors included the application of four levels of selenium (0, 20, 40, 60 g SeO4 ha^{-1}) and three levels of phosphate (0, 90, 180 kg P ha^{-1}). The results showed that increasing the concentrations of the two elements and increasing their readiness in the soil solution led to an increase in their absorption by the plant roots and an increase in their role in improving growth.

Keyword. absorption phosphorus, Maize.

Introduction

Phosphorus is a vital nutrient for plant growth and development. It is involved in important metabolic activities like energy transmission, signal transduction, macromolecule production, photosynthesis, and respiration. Additionally, it acts as a crucial determinant that restricts the long-term viability of maize cultivation [1]. Phosphorus, considered a crucial nutrient and the second most significant element in biological construction following nitrogen, exerts a distinctive influence on energy transfer and cytological processes, encompassing nutrient uptake. The predominant form of phosphorus in the environment exists in a highly oxidized state, primarily as phosphate, and tends to form insoluble chemical complexes with calcium, iron, and aluminum, thereby impeding its absorption by plants [2]. Maize (Zea mays L.), a vital cereal crop renowned for its adaptability to diverse climatic conditions, has witnessed a substantial surge in production in recent decades. Global estimates project that approximately 1974 million tons of corn will be cultivated worldwide in 2020, with the United States emerging as the leading producer, contributing to 36% of the world's total corn output [3]. Maize is recognized for its versatility, being utilized in the production of a wide array of food and non-food products, including food items, beverages, biofuels, and biodegradable plastics, among others. With escalating population growth and food demand, there is a pressing need to enhance maize production on a global scale to meet these increasing requirements

[4]. The utilization of phosphate fertilizer in agricultural production was 43.8 million tons in 2015 and is projected to increase to 52.9 million tons by 2030 [5]. Considering that mineral phosphate is a finite and restricted resource, it is imperative to engage in research focused on the development and identification of maize varieties that exhibit high phosphorus use efficiency (PUE). This endeavor not only aims to reduce the dependency on phosphorus fertilizers but also seeks to ensure the sustainability of maize production practices for the future [6]. This study aims to assess the impact of escalating phosphorus levels on the concentration of anions in Zea mays L. plants

Material and Methods

Materials and working methods.

Soil samples were gathered from a depth of 0-30 cm, transported to the laboratory, air-dried, and cleared of impurities. Subsequently, they were ground, sieved using a 2mm sieve, and stored in plastic containers for analysis and experimental procedures as outlined in Table 1 [7].

Table 1: Selected characteristics of soil used for the adsorption study.

Soil properties	Agriculture College soil (S1)	Horticulture station soil (S2)
Clay (%)	43	30
Silt(%)	35	60
Sand(%)	22	10
Texture	Clay	SiltyClay Loam
pH	7.6	7.7
$CaCO_3$(%)	35.6	29
EC(dS m^{-1})	6.8	5.8
O.M (%)	15	12

2.2. Biological experiment.

Using a completely randomised design (CRD) in plastic pots with two different textures of soil, the biological (agricultural) experiment was carried out in the wood canopy of the Department of Horticulture at the College of Agriculture - Al-Qasim Green University during the summer agricultural season. First soil, designated S1, came from the College of Agriculture in Babylon and was Clay in consistency. Second soil, designated S2, came from the Karbala horticultural station and was Silty Clay Loam in consistency. Different levels of phosphate (3 levels: 0, 90, and 180 kg P ha^{-1}) and selenium (4 levels: 0, 20, 40, and 60 g SeO4 ha^{-1}) were used in the experiment. To avoid vegetative component contamination, plants were harvested 65 days after planting at a height of 1.5 cm from the soil's surface. To remove any remaining soil particles suspended in the harvested plants, distilled water was used for cleaning. The plants were then chopped, ground with an electric grinder, and kept in plastic containers for examination after being dried at 50 °C for a set weight. For the experiment, plastic pots with dimensions of 15 cm in height and 18 cm in diameter were used.

After the proper soaking, grinding, and aeration, each pot held 3 kg of soil that had to pass through a 4 mm sieve. After seven days of emergence, the number of plants in each pot was lowered to five from the initial ten maize seeds put in each pot. After being harvested 65 days after it first appeared, the maize was cleaned with distilled water, dried, and then its concentration was determined using an atomic absorption device, the Shimadzu/AA-7000.

2. 3. Measure the concentration of phosphorus in the plant.

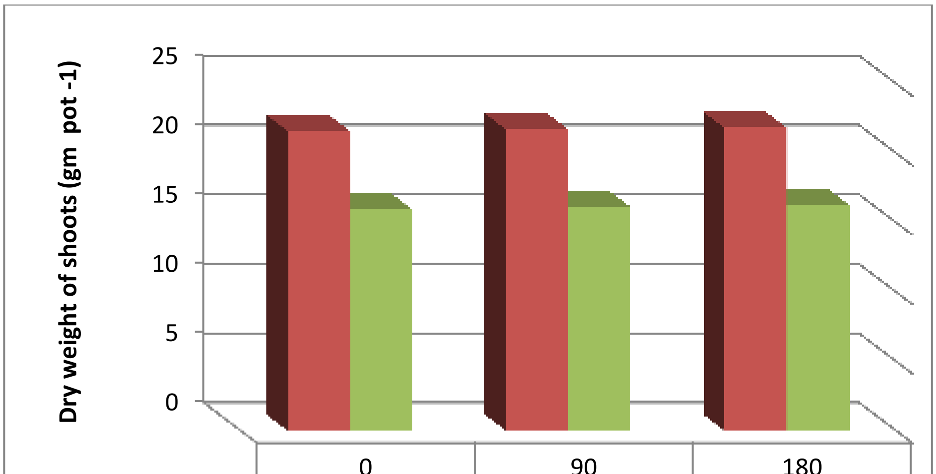
The dry plant samples were subjected to digestion using concentrated sulfuric acid and perchloric acid with heating, in accordance with the specified method [8]. Subsequently, the estimation of phosphorus in the plant material was carried out utilizing the molybdate-ammonium phenate reduction method [9]. To use this approach, 22.5 gm of ammonium molybdate was dissolved in 400 ml of distilled water to create Solution A. Separately, 1.25 gm of ammonium phenate was dissolved in 300 ml of hot distilled water to generate Solution B. Following the addition of Solution B to Solution A, the mixture was allowed to cool. The volume of the mixture was then carefully increased to 1 liter after 250 ml of nitric acid (HNO3) was added. In order to proceed, 5 ml of the broken-down plant material was combined with 5 ml of an ammonium molybdate-ammonium vanadate solution. After adding distilled water to get the level to 50 ml, the mixture was allowed to stand for 30 minutes. Ultimately, the quantity of phosphorus in the samples was ascertained by measuring the optical absorbance at 410 nm using a spectrophotometer.

2.4. Calculating the amount of absorbed phosphorus.

After recording the dry weight and phosphorus concentration, the amount absorbed into the plant samples was calculated through the following relationship. Amount of absorbed phosphorus = weight of dry matter x phosphorus concentration in the plant

Results and Discussion

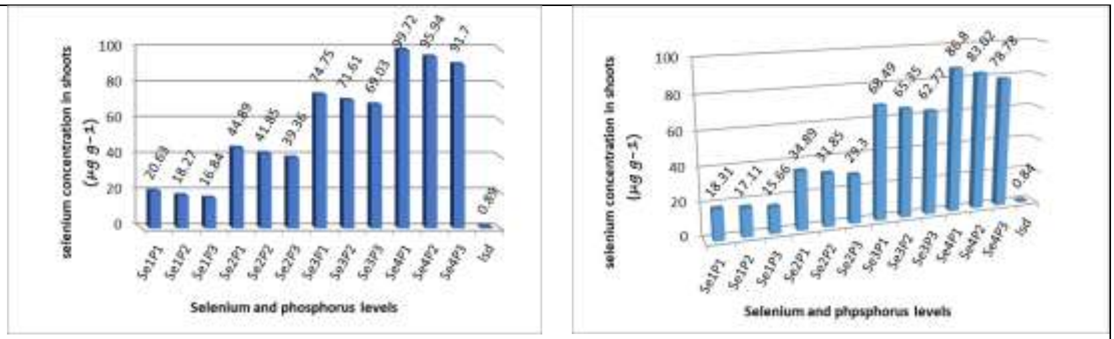
Figure 1 illustrates the notable impact of adding PO4 phosphate at levels of 0, 90, and 180 kg P ha^{-1} on the dry weight of the plant. The dry weight increased from 21.60 to 21.71 and 21.82 g P ha^{-1}, resulting in increases of 0.50% and 1.02% for the soil of the College of Agriculture and the soil of the gardening station, respectively. The weight of pot-1 increased from 15.95 gm to 16.11 gm and then to 16.26 gm, with growth rates of 1.00% and 1.94% respectively.



	0	90	180
S1	21.6	21.71	21.82
S2	15.95	16.11	16.26

Fig 1. Effect of phosphorus levels on plant dry weight

The plant's dry weight increases as the level of phosphorus addition increases. This is due to the plant's increased readiness to absorb phosphorus and its increased involvement in the production of ATP, which represents the mineral form of phosphorus after it is absorbed by the plant [10]. Fig 2. Shows that there are significant differences in the dry weight of yellow maize plants when selenium and phosphorus interact. The weights of the plants ranged from 20.28-22.63 and 15.66-78.78 gm pot $^{-1}$ for the College of Agriculture and the horticulture station, respectively. There was an increase of 11.58% and 29.48% compared to the control treatment, which is consistent with [11]. Plant roots absorbed more of the two elements, and they had a larger role in enhancing growth when their concentrations and readiness in the soil solution were increased.



S1 S2

Figure 2: The impact of selenium and phosphorus interactions on plant dry weight

3.2. The effect of phosphorus addition on plant phosphorus content

By increasing the level of phosphorus addition to the soil to 90 and 180 kg P ha-1, respectively, the plant phosphorus concentration rose from 4.97 to 5.07 and 5.2 g P kg-1 dry matter in the agricultural college soil, and from 3.8 to 3.91 and 4.04 g P kg-1 dry matter in the gardening station soil (Fig3). One possible explanation is that it becomes more available in the soil, which in turn increases its concentration and absorption by the plant. It is in line with the findings of [12,13] that higher soil phosphorus inputs resulted in noticeably higher phosphorus concentrations in yellow maize plants. As the amount of phosphorus added to the soil grew from 90 to 180 kg P ha-1 for both soils, the plant phosphorus concentration also increased.

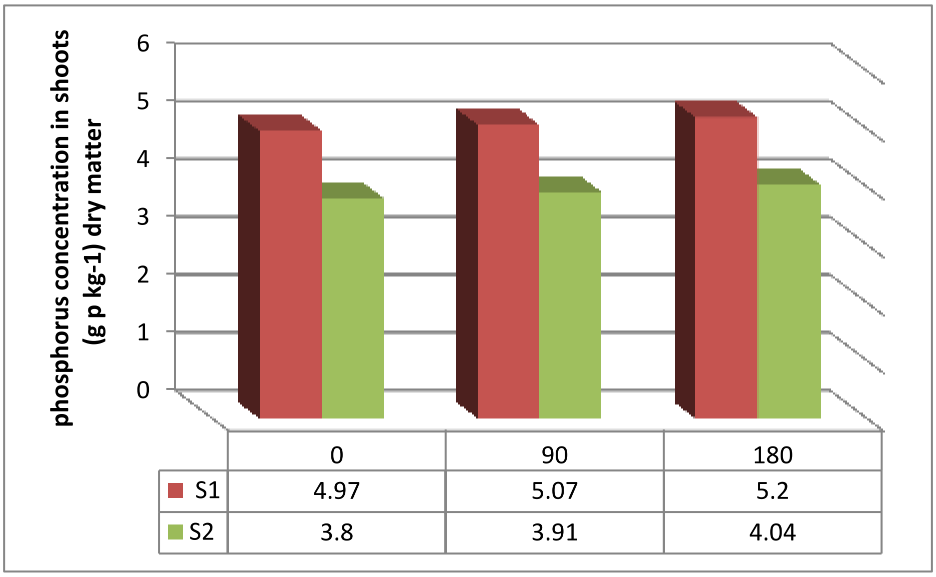


Figure 3: The impact of phosphorus addition to the research soil on the dry matter content of phosphorus in plants

(g P kg-1)

3.3. The absorbed amount of phosphorus.

The amount of phosphorus that the plant absorbed increased from 0.05 to 0.06 and 0.07 gm P ha^{-1}, with a 20% and 20% rate of increase, respectively, for the soil of the College of Agriculture (Fig. 4). Similarly, for the soil of the gardening station, the amount of phosphorus that the plant absorbed increased from 0.028 to 0.030 and 0.033 gm P ha^{-1}, with a 7.14% and 17.86% rate of increase, respectively (Fig. 4). This is the best way to organize the phosphorus levels that plants in the research soil absorbed:

College of Agriculture > Horticulture Station

The soils' physical and chemical properties (Table 1) might explain this.

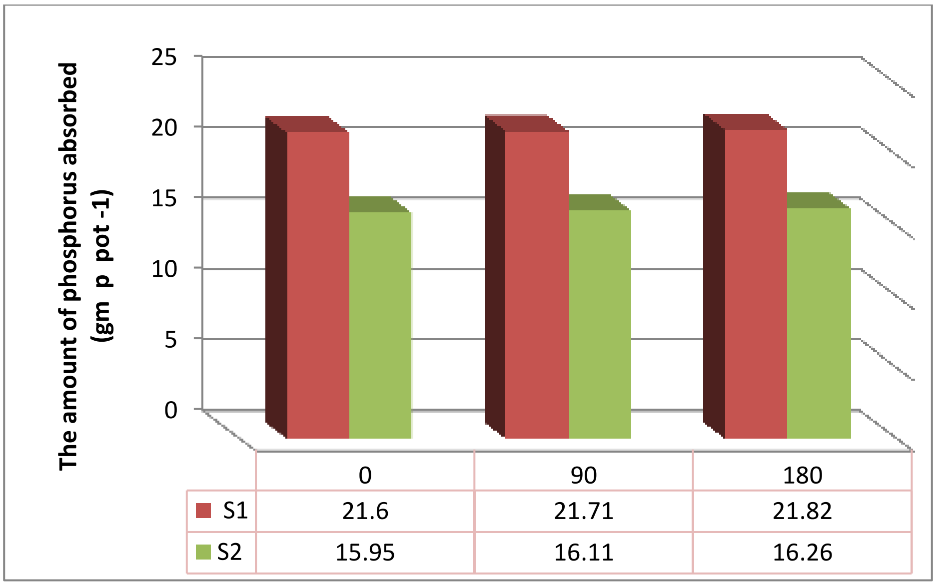


Figure 4. The effect of adding phosphorus levels on the amount of phosphorus absorbed by plants into the soil.

References

[1] Al-Tememi, A. J., and Abu-dahi, Y. M. 2010. ROLE OF APPLICATION LEVELS OF PHOSPHORUS TO SOIL AND SPRAY ON GRAIN YIELD AND ITS QUALITY BY MAIZE. *Iraqi Journal of Agricultural Sciences*, *41*(4).

[2] Khademi, Z., Balali, M. R., and Malakouti, M. J. 2001. Corn yield and potassium accumulation related to potassium fertilizer rates. *Plant Nutrition: Food security and sustainability of agro-ecosystems through basic and applied research*, 824-825.

[3] **Uchida, R. 2000.** Essential nutrients for plant growth: nutrient functions and deficiency symptoms. *Plant nutrient management in Hawaii's soils*, *4*, 31-55.

[4] Liu, Q., Wang, D. J., Jiang, X. J., and Cao, Z. H. 2004. Effects of the interactions between selenium and phosphorus on the growth and selenium accumulation in rice (Oryza sativa). *Environmental geochemistry and health*, *26*, 325-330.

[5] AbdulKadium, S. M., and Al-Janabi, H. Y. A. 2023. Effect of the Addition of Selenium and some Competing Anions on Selenium Concentration in Maize Growing in some Soils in Central Iraq. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1158, No. 2, p. 022034). IOP Publishing.

[6] Patorczyk-Pytlik, B., and Zimoch, A. 2011. The effect of soil fertilization with phosphorus on the content of selenium in white mustard plants (Sinapsis alba L.). Rada Konsultacyjna–Advisory Board.

[7] Page, A. L. (Ed.). 1982. *Methods of soil analysis. Part 2. Chemical and microbiological properties* (pp. 1159-pp).

[8] Cresser, M. S., and Parsons, J. W. 1979. Sulphuric—Perchloric acid digestion of plant material for the determination of nitrogen, phosphorus, potassium, calcium and magnesium. Analytica Chimica Acta, 109(2), 431-436.

[9] Al-Mharib, M. Z. K., Al-Saadi, F. M. J., and Almashhadany, A. H. 2020. Studies on growth and yield indicators for kohlrabi (Brassica oleracea) plant treated with mineral fertilizers and root enhancers. Research on Crops, 21(2), 333-338.

[10] Mengel, K., and Kirkby, E. A. 1987. *Principles of plant nutrition* (No. Ed. 4, p. 687pp).

[11] Nakamaru, Y. M., and Altansuvd, J. 2014. Speciation and bioavailability of selenium and antimony in non-flooded and wetland soils: A review. *Chemosphere*, *111*, 366-371.

[12] AJEMA GEBISA, L. E. T. A. 2019. *RESPONSE OF COFFEE (Coffea arabica L.) SEEDLINGS TO POT SIZES AND BIOCHAR BASED MEDIA COMPOSITION AT AWADA, SOUTH ETHIOPIA* (Doctoral dissertation, JIMMA UNIVERSITY).

[13] Abed, M. A. K., Al-Asadi, R. M. S., and Kadium, S. M. A. 2022. Modelling the Percentage of the Exchangeable Magnesium Based on the Adsorption Ratio in the Some Saline Soils Central Iraq. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1060, No. 1, p. 012003). IOP Publishing.