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Comparison of Urea-Phosphate with other Available NP Based Fertilizers for Phosphorus Effect on Maize Growth Parameters

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ABSTRACT To maintain the production of crop and fertility of soil, balanced fertilizers are required. The use of fertilizer and their ratio is investigated as improper ratio and use of fertilizer because yield lose. In current experiment, urea-phosphate fertilizer was compared with other phosphorus and nitrogen containing products like diammonium phosphate (DAP) and nitro-phos. For this purpose, an experiment was carried out in randomized block design on research farm to test the different phosphorus containing products on 13 studied attributed which includes Plant height, Number of leaves per plant, growth rate of plant, cob length, number of grain lines per cob, number of grains per cob, biological yield, grain yield, 1000 grain weight, harvest index, photosynthesis rate, transpiration rate and sub-stomatal CO2 conductance. The results revealed that when urea-phosphate applied at recommended ratio, the plants showed best results as compared to the nitro-phos and diammonium phosphate (DAP). The urea-phosphate has low pH which increase the efficiency of N and P by fixing the phosphorus fixation and ammonium volatilization. Thus, the use of urea-phosphate may improve the production of the crop and soil fertility with enrich efficiency of N and P and may reduce the environmental health and safety.

Keywords: *maize; urea-phosphate; ammonium volatilization; nitro-phos; DAP*

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INTRODUCTION The maize (Zea mays L.) is a perennial member of the Poaceae family from the Maydeae tribe is a cross-pollinated annual cultivated plant. Many essential elements maybe found in the maize grain that is commonly referred as corn grain. There is 9.6 % moisture, 5.4 % of the ether extracts, 1.7 % ash, 2.2 % fiber, 3-18 % oil, 10.7 % protein and 70.4 % carbohydrates found in maize flour (Cheptoek et al., 2021; Zafar, Abbasi, & Khaliq, 2013). On a hectare basis maize crop is third largest after wheat and rice in Pakistan. According to Economic Survey of Pakistan 2020-21, maize occupies area of 1418 thousand hectares with an average grain yield of 8.46 million tons in 2020-21, which is significantly lower than the global average of 9.59 metric tons per hectare (USA), 5.46 metric tons per hectare (Chinese), and 4.37 metric tons per hectares (Brazilian).

The lack of plant nutrients in the soil is a major contributor to the low yield of the crop. The key to increasing and maintaining agricultural output is to use necessary plant nutrients in the proper proportion and dosage. Crops require sixteen different elements in order to reach their full potential and vigor. Macro and micro elements are broken down into two categories. Plants require larger concentrations of the major elements (Ca, Mg, S, N, P, K, C, H and O) than the minor elements (B, Mo, Zn, Cu, Mn, Fe, and Cl). There must be sufficient quantities and forms of each of these critical components in the soil for crop plants to take advantage of.

Fertilizer use has major contribution in crop production and can be used in efficient way to achieve crop yield on sustainable basis. Increase in crop production through fertilizer application rate is greater than 50%, globally. However, for the exploitation of existing yield potential of crops, to meet the ever-increasing food demand, to minimize the environmental pollution and to get sustainable production, it is needed to increase the fertilizer use efficiency of different fertilizers. Nutrient efficiency is the fraction of the removed nutrients by harvested crop from the soil (Chatterjee, 2012). The yield obtained per unit application of nutrient also called nutrient use efficiency which consists of two components; (i) the ability to take up nutrients from soil that is uptake efficiency and (ii) the ability to assimilate for yield development which is called utilization or physiological efficiency of nutrients (Ortiz-Monasterio, Manske, & Van Ginkel, 2001).

The run-off and leaching of N and P lead to environment degradation (Gyaneshwar, Naresh Kumar, Parekh, & Poole, 2002) which causes low fertilizers use efficiency (Adesemoye & Kloepper, 2009). In different areas of Western Europe, China, and the USA, use rate of N and P is higher than the crops need which resulted in low nutrient use efficiency (NUE) (Ademba, Kwach, Ngari, Esilaba, & Kidula, 2014; Khan, Iqbal, & Islam, 2007). The soil and water pollution due to these applications rate is major issue of the regions (Ma et al., 2011; Ott & Rechberger, 2012; Vitousek et al., 2009).

This can also be improved by using different ways of application such as soil application, fertigation and foliar spray, and/or integration of these three methods The major underlying objective is to enhance yield and quality of the produce (Chlorophyll synthesis increased in the leaves through foliar application of N. Nutrient uptake occurred both via stomata present in leaf and hydrophilic pores in the cuticle layer of leaf (Kogbe & Adediran, 2003; Timilsena et al., 2015) Different factors such as soil conditions and crop type affect the efficiency of soil application and foliar applied nutrients (Kumar et al., 2022).

The objectives of this study were to explore the release pattern of N and P based formulated urea-phosphate in soil, selection of the best fertilizer application method (soil, fertigation and foliar) for higher maize crop production and comparative analysis of the fertilizer use efficiency of commercially available fertilizers with formulated urea-phosphate fertilizer.

MATERIAL AND METHODS

In this field study, Nitrogen and Phosphorous based fertilizer Urea-Phosphate was compared with other N and P containing fertilizers such as nitro-phos and diammonium phosphate (DAP). This experiment was laid out in randomized complete block design (RCBD) and carried out on a research farm, Jamshaid Farms, 8SP Tehsil and district, Pakpattan. Land was ploughed followed by planking and rotavated, then beds were prepared by bed planter. Maize variety "Sohni-Dharti 626" was sown as test crop at the seed rate of 25 kg ha-1 on 24 July 2021. Standard agronomic practices were followed, irrigation was applied whenever needed, and weedicides (Gangwi @ 1000 ml per acre) and insecticides were applied according to the requirements (pest attack and scouting). The crop was harvested on 15th November 2021. Four treatments were subjected to the maize plants control, nitro Phos, DAP and NP based urea-phosphate. Recommended dosage of N: P: K was applied with the application rate of 175:125:125 per hectare with proper split dosage of nitrogen in 3rd and 4th irrigation.

The data of 13 different attributes of maize plant were collected and analyzed which were Plant height, Number of leaves per plant, growth rate of plant, cob length, number of grain lines per cob, number of grains per cob, biological yield, grain yield, 1000 grain weight, harvest index, photosynthesis rate, transpiration rate sub-stomatal CO2 conductance and

Urea-phosphate use efficiency = Grain yield fertilized plot – Grain yield in control____
Applied urea-phosphate

RESULTS

The height of maize plants was markedly influenced by different phosphatic fertilizers. Urea-phosphate gave very encouraging results by producing plants with longer length with 255 cm plant height followed by DAP (235 cm) while Nitro-phos gave minimum plant height related to other phosphate fertilizers that was only 6 % higher than control as represented in the figure 1A.

The number of leaves per plant were highly influenced by source of fertilizer Nitro Phos, DAP and urea phosphate produces more leaves per plant by 14%, 36% and 50% as compared to control respectively as indicated in the figure 1B.

The crop growth showed better results with the application of urea phosphate with 42% more efficiency as compared to DAP and nitro Phos with the rate of 25% and 17% respectively as compared to control as represented in figure 1C.

Urea-phosphate produced longest cobs that were 56 % longer than control cobs while DAP and nitro Phos produced 38% and 25% higher cob length respectively as compared to control as represented in 1D.

Highest response of urea phosphate on maize was recorded that induced 62% higher grain lines per cob than control while DAP and nitro Phos with efficiency rate of 23% and 15% respectively as compared to control as indicated in the figure 2A.

Number of grains per cob was strongly influenced by P fertilizer source. Urea-Phosphate, DAP and nitro Phos gave similar results like grain lines per cob with the efficiency rate of 29%, 18% and 11% as compared to control as represented in the figure 2B.

Control plot gave minimum 1000 grain weight with the value of 235g while nitro Phos, DAP and urea-phosphate gave the values of 240g, 248g and 255g respectively. Various phosphatic fertilizers showed a strong concern over 1000 grain weight of maize as depicted in Figure 2C. Biological yield was found non-significant among DAP and nitro Phos as both fertilizers induced 14 t ha-1 biological yield but it was higher than control that induced 13 t ha-1. However, highest biological yield (16 t ha-1) was given by urea-phosphate that was significantly higher than all other treatments as depicted in the figure 2D.

As depicted in Figure 3A, grain yield of maize was strongly influenced by P fertilizer sources. Urea-phosphate gave maximum grain yield (that was 5.9 t ha-1) followed by DAP that gave 5.6 t ha-1while Nitro Phos gave 5.4 t ha-1 and control produced least grain yield by giving only 5 t ha-1.

As represented in the Figure 3B, photosynthetic rate was maximum with urea-phosphate (15 µmol m-1 s-1) followed by DAP (13 µmol m-1 s-1), nitro Phos (12 µmol m-1 s-1) and then control (10 µmol m-1 s-1). A similar trend was observed for transpiration rate as given in the figure 3C where minimum rate was given by control that was 6.5 µmol m-1 s-1 and it was gradually increased with the application of nitro Phos (7.5 µmol m-1 s-1), DAP (8 µmol m-1 s-1) and urea-phosphate (10.5 µmol m^{-1} s-1). As illustrated in Figure 3D, the sub-stomatal CO2 flux was under the strong influence of different P fertilizer sources. Control treatment where no P fertilizer was applied showed minimum sub-stomatal CO2 flux (700 µmol mol-1). DAP showed 824 µmol mol-1, nitro Phos showed 780 µmol mol-1 and maximum sub-stomatal CO2 flux was given by urea-phosphate that was 900 µmol mol-1.

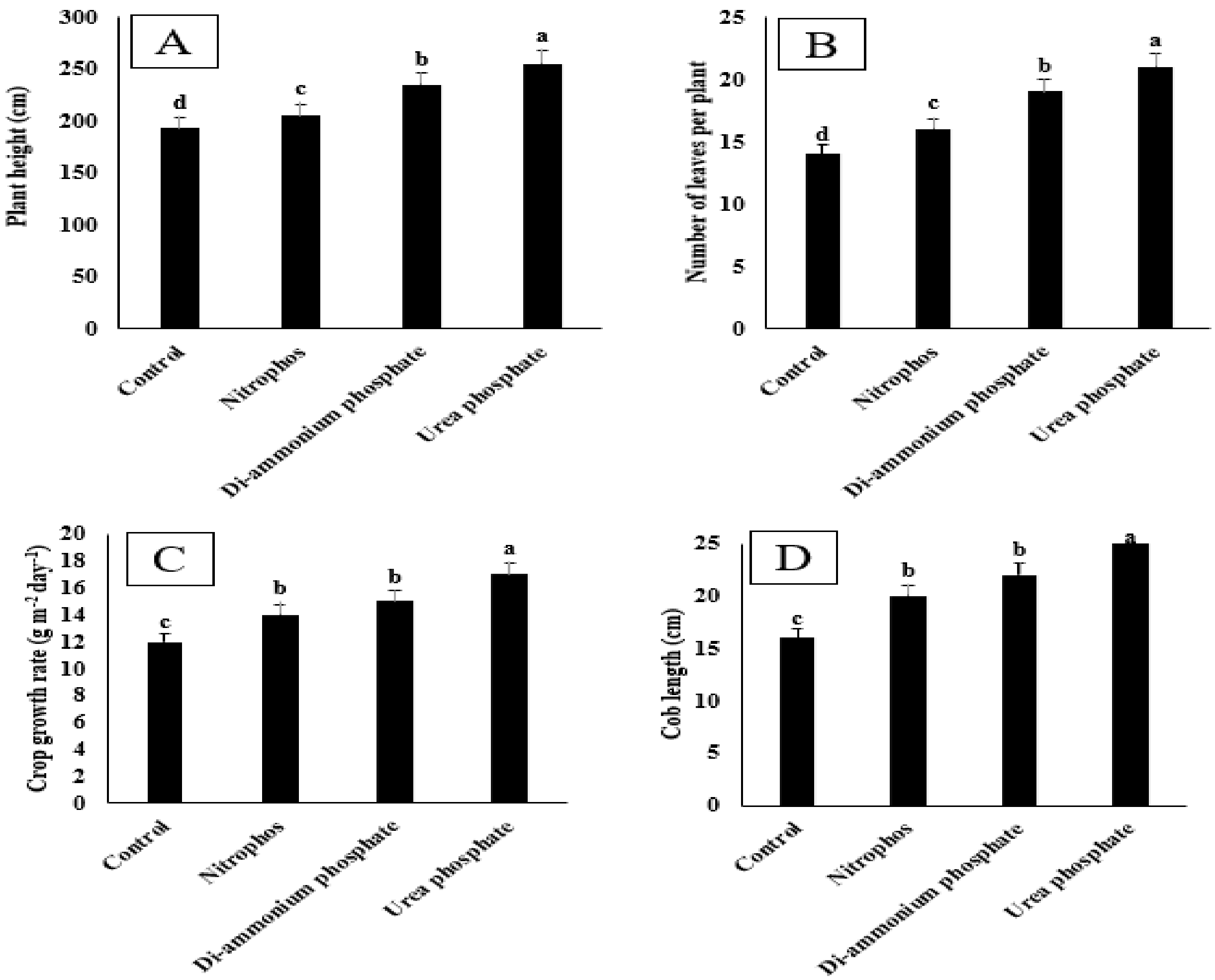

Figure 1: Effect of different phosphatic fertilizers on (A) plant height, (B) number of leaves per plant, (C) crop growth rate (g $m^{-2}day^{-1}$) and (D) cob length of maize (Similar letters on bars are showing non-significant results)

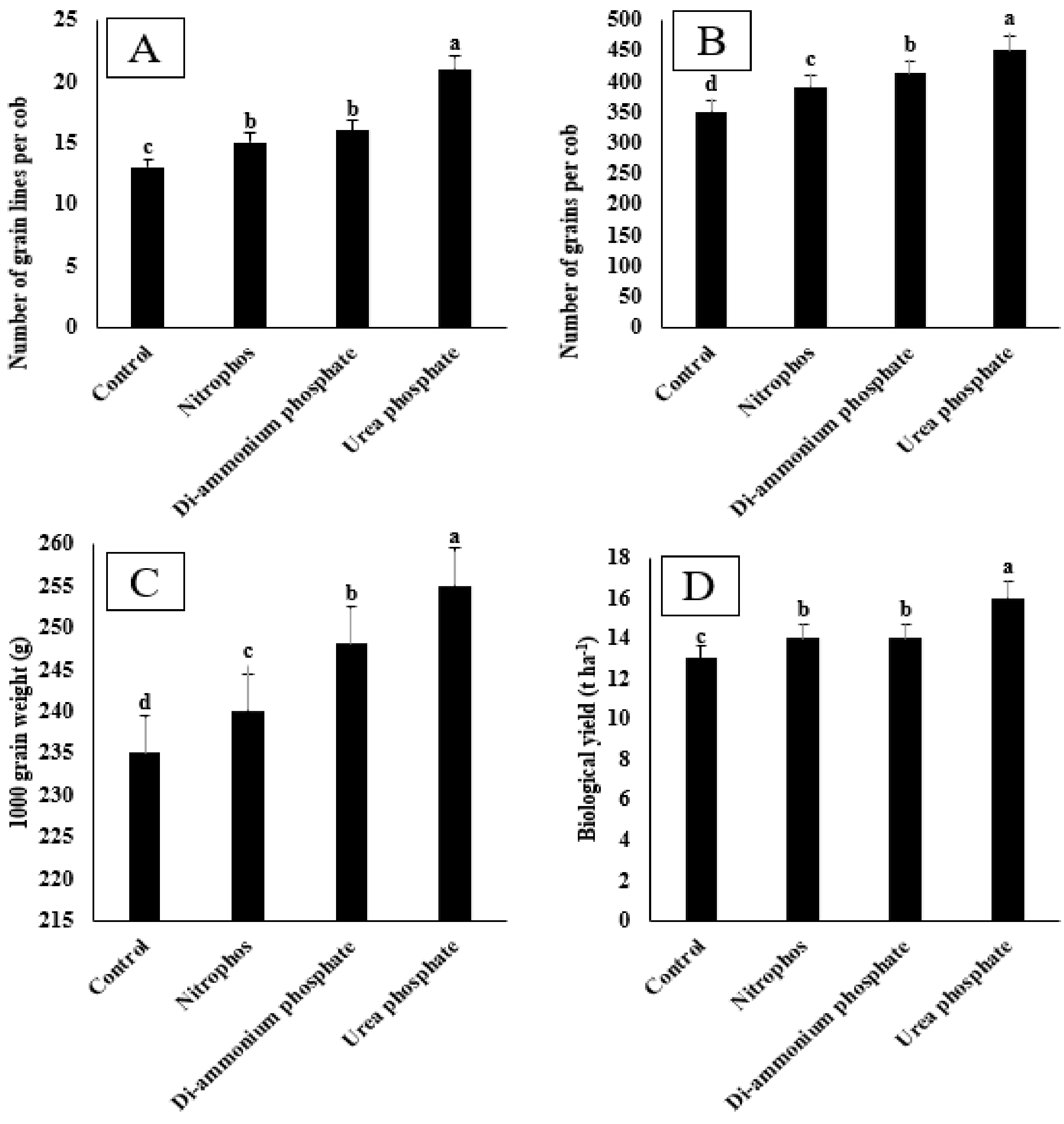

Figure 2: Effect of different phosphatic fertilizers on (A) number of grain lines per cob, (B) number of grains per cob, (C) 1000 grain weight and (D) biological yield (t ha^{-1}) of maize (Similar letters on bars are showing non-significant results)

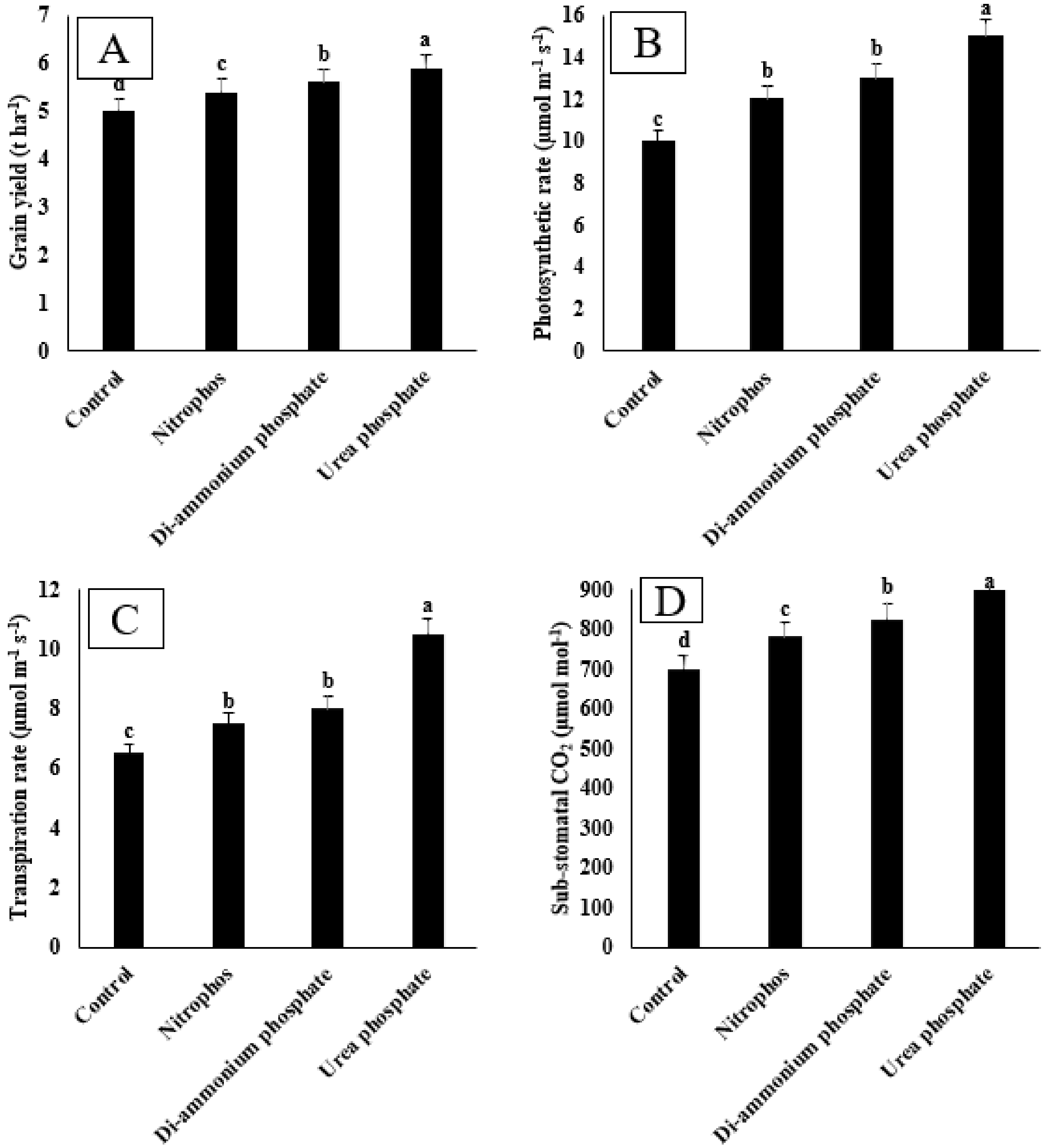

Figure 3: Effect of different phosphatic fertilizers on (A) grain yield (t ha^{-1}), (B) photosynthetic rate (µmol m^{-1} s^{-1}), (C) transpiration rate (µmol m^{-1} s^{-1}) and (D) sub-stomatal CO_2 (µmol mol^{-1}) of maize (Similar letters on bars are showing non-significant results)

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DISCUSSION

The maximum productivity potential in agriculture in most places of the globe is constrained by the lack of phosphorus (P)which is the most essential element after nitrogen (Cheptoek et al., 2021; Kogbe & Adediran, 2003).

Due to their restricted root system and thin stems that result from phosphate deficiency, stunted plants are unable to thrive. In many cases, the grain production is drastically decreased. Phosphorus is concentrated in the seeds of plants, which are often collected. Premature crops tend to have a lower phosphorus content than younger crops and supply just a tiny portion of the phosphorus needed by the following harvest.

Phosphorus (P) and nitrogen (N) are required as essential macronutrients in balanced nutrition plan, because they are involved in various metabolic processes like energy transfer, photosynthesis and metabolism of carbohydrates. Although P is present in both mineral and organic form in soils, only very low fraction of soil P is available for plants. To meet the desired goal of crop yield, synthetic fertilizers of P thus should be applied in many cases (Hopkins, Rosen, Shiffler, & Taysom, 2008; Zafar et al., 2013). Plants generally take up P in the form of orthophosphates (H2PO4- and HPO4-2). The proportion of these forms taken up by the plants is determined by soil pH. At high soil pH, more HPO4-2 is taken-up in comparison to H2PO4- (Khan et al., 2007). In Pakistani soils, there is an issue of its availability, as our soils are alkaline in reaction, calcareous in nature and low in organic matter. Due to these conditions, P is fixed mainly and becomes unavailable to plants (Kumar et al., 2022; Zaidi, Khan, & Amil, 2003). Thus, P use efficiency becomes very low (5-20 % in comparison to normal conditions). So, to get a higher grain yield, P use efficiency should be enhanced to get more grain yield (ME Trenkel, 2021).

Low nutrient use efficiency is one of the major reasons of low crop yield in Pakistan. Therefore, a series of laboratory and field experiments were conducted to enhance the nutrient use efficiency of NP-based formulated fertilizer in maize applied through soil, fertigation, and foliar. The results obtained in the field experiment conducted in Jamshaid Farms, 8/SP Tehsil and District, Pakpattan. the comparison of urea-phosphate regarding NP uptake, efficiency, and maize growth with other available NP-based fertilizers (NP and DAP) was investigated. The field experiments were designed in randomized complete block design in factorial arrangement with three replications.

Results indicated that reduced rates of urea-phosphate (75 and 50 % of recommended) showed good results with respect to the growth and yield parameters of crop in comparison to the control treatment. While maximum plant height and grain yield were observed when 75 % of the recommended rate of urea-phosphate was applied in comparison to all other rates (Dhillon, Torres, Driver, Figueiredo, & Raun, 2017; Shenoy & Kalagudi, 2005). This improvement in the growth and yield of maize might be due to the consistent supply of P and good early root growth. (Fageria & Baligar, 1997; Yaseen et al., 2017) reported that the growth improvement is mainly due to good early root growth and readily applied P. Similarly, (Timilsena et al., 2015) reported that the consistent P supply improved the growth and yield components of wheat, resulting in an increase in grain yield.

Results also depicted that photosynthetic rate, transpiration rate and sub-stomatal CO2 flux were enhanced by the application of urea-phosphate at the rate of 75 % of recommended rate (Sattar et al., 2021). This might be due to less fixation of P in the soil and more P availability to plants for their normal metabolic activities. In line with our findings, (Zafar et al., 2013) found that less exposure of P to soil system leads to less P fixation. (Noor, Yaseen, Naveed, & Ahmad, 2017) also reported that P use efficiency of wheat was increased by the application of value-added DAP.

Effect of urea-phosphate on the growth, yield and urea-phosphate efficiency of maize was evaluated under field conditions. Results indicated that yield and yield components of maize were significantly improved with the use of urea-phosphate over control treatment. This might be due to the acidic conditions created around fertilizer granule due to the application of urea-phosphate in the soil. Due to these acidic conditions, P fixation in soil becomes lower, secondly most of the micronutrients becomes available at lower pH. Thus, the increased yield of maize could be the consequence of this trait. In a similar way, (Iqbal et al., 2012; Monica, Dash, Panda, & Prusty, 2020) described that with the application of urea-phosphate, the grain yield and plant height of wheat was significantly enhanced over DAP due to the acidic conditions generated in the soil (Ademba et al., 2014; Arif et al., 2017). This is probably due to the improved root growth of maize, as root length and weight were maximum with 75 % of recommended rate of urea-phosphate. (Azeem, KuShaari, Man, Basit, & Thanh, 2014) also documented that coated fertilizers enhanced the nutrient availability and root growth of wheat because plant height of wheat was increased. Other growth, physiological and yield parameters of maize like chlorophyll contents, 1000 grain weight and grain yield were also enhanced by the application of urea-phosphate even at reduced rates with the maximum outcome with 75% of recommended rate of urea-phosphate. (Al-khafagi, Al-gebori, & Mohammed, 2016; Arif et al., 2017) demonstrated that urea-phosphate along salicylic acid application boosted the growth, 1000 grain weight and yield of Allium cepa L. 22% extra wheat yield was obtained by using optimal application of phosphorus.

When urea-phosphate was compared to other phosphatic fertilizers, it was discovered that urea-phosphate application resulted in the maximum plant height, number of leaves per plant, crop growth rate, and cob length when compared to other P fertilizers. This might be due to the N contents present in urea-phosphate, as N is involved in the better vegetative growth of crop plants. N stimulates the metabolic activities in the plant body to accelerate its vegetative growth resulting in rapid growth rate. In line with our findings (Ochmian, Oszmiański, Jaśkiewicz, & Szczepanek, 2018) stated that urea-phosphate boosted the total N contents in the soil. The best results in terms of growth and physiological traits were observed with urea-phosphate over all other fertilizers. These results might be attributed to the P proportion of urea-phosphate, as second highest outcomes were obtained from DAP. Similarly, (Iqbal et al., 2012) proved urea-phosphate was a better fertilizer for wheat growth than other NP-based fertilizers.

CONCLUSION

A balanced application of essential nutrients, particularly N and P, may help in achieving the optimum yield on a sustainable basis. However, excessive fertilizer use results in nutrient losses via leaching/surface run-off, which pollutes underground water and cause eutrophication, volatilization, which result in greenhouse effect by depleting ozone layer. While lower use of N and P might lead to yield loss. Therefore, the use of urea phosphate fertilizer, which has low pH that can enhance the N and P use efficiency by reducing P-fixation and ammonia volatilization. The use of this acidic fertilizer also enhanced the growth and production of the maize crop under field conditions while the other fertilizer like DAP and Nitro Phos showed decreased yield and potential in the crop. Thus, the soil application of urea-phosphate at the recommended rate may improve crop yield with enhanced N and P use efficiency and minimum risk of environmental health and safety.

REFERENCES

Ademba, J. S., Kwach, J. K., Ngari, S. M., Esilaba, A. O., & Kidula, N. L. (2014). Evaluation of organic and inorganic amendments on nutrient uptake, phosphorus use efficiency and yield of maize in Kisii County, Kenya. African Journal of Agricultural Research, 9(20), 1571-1578.

Adesemoye, A. O., & Kloepper, J. W. (2009). Plant–microbes interactions in enhanced fertilizer-use efficiency. Applied microbiology and biotechnology, 85, 1-12.

Al-khafagi, A. M., Al-gebori, K. D., & Mohammed, S. O. (2016). Impact of foliar application by urea phosphate and salicylic acid on the growth and seed yield of Allium cepa L. Euphrates Journal of Agriculture Science, 8(4), 63-71.

Arif, M., Ilyas, M., Riaz, M., Ali, K., Shah, K., Haq, I. U., & Fahad, S. (2017). Biochar improves phosphorus use efficiency of organic-inorganic fertilizers, maize-wheat productivity and soil quality in a low fertility alkaline soil. Field crops research, 214, 25-37.

Azeem, B., KuShaari, K., Man, Z. B., Basit, A., & Thanh, T. H. (2014). Review on materials & methods to produce controlled release coated urea fertilizer. Journal of controlled release, 181, 11-21.

Chatterjee, A. (2012). Reducing denitrification loss of nitrogen fertilizer. Crop and Soil Magazine, 45, 14-15.

Cheptoek, R. P., Gitari, H. I., Mochoge, B., Kisaka, O. M., Otieno, E., Maitra, S., . . . Seleiman, M. F. (2021). Maize productivity, economic returns and phosphorus use efficiency as influenced by lime, Minjingu Rock Phosphate and NPK inorganic fertilizer.

Dhillon, J., Torres, G., Driver, E., Figueiredo, B., & Raun, W. R. (2017). World phosphorus use efficiency in cereal crops. Agronomy Journal, 109(4), 1670-1677.

Fageria, N., & Baligar, V. (1997). Phosphorus-use efficiency by corn genotypes. Journal of plant nutrition, 20(10), 1267-1277.

Gyaneshwar, P., Naresh Kumar, G., Parekh, L., & Poole, P. (2002). Role of soil microorganisms in improving P nutrition of plants. Plant and soil, 245, 83-93.

Hopkins, B. G., Rosen, C. J., Shiffler, A. K., & Taysom, T. W. (2008). Enhanced efficiency fertilizers for improved nutrient management: potato (Solanum tuberosum). Crop Management, 7(1), 1-16.

Iqbal, Z., Yaqub, M., Lodhi, A., Tahir, S., Akhtar, M., Qureshi, T. M., & Naeem, A. (2012). Evaluation of urea phosphate as a phosphorus source for wheat crop in comparison to DAP in calcareous soil. International Journal of Biology and Biotechnology (Pakistan).

Khan, A. U., Iqbal, M., & Islam, K. (2007). Dairy manure and tillage effects on soil fertility and corn yields. Bioresource technology, 98(10), 1972-1979.

Kogbe, J., & Adediran, J. (2003). Influence of nitrogen, phosphorus and potassium application on the yield of maize in the savanna zone of Nigeria. African journal of biotechnology, 2(10), 345-349.

Kumar, K., Yadava, P., Gupta, M., Choudhary, M., Jha, A. K., Wani, S. H., . . . Rakshit, S. (2022). Narrowing down molecular targets for improving phosphorus-use efficiency in maize (Zea mays L.). Molecular Biology Reports, 49(12), 12091-12107.

Ma, W., Ma, L., Li, J., Wang, F., Sisák, I., & Zhang, F. (2011). Phosphorus flows and use efficiencies in production and consumption of wheat, rice, and maize in China. Chemosphere, 84(6), 814-821.

ME Trenkel, T. (2021). Slow-and Controlled-Release and Stabilized Fertilizers: An Option for Enhancing Nutrient Use Effiiency in Agriculture: International Fertilizer Industry Association (IFA).

Monica, M., Dash, A., Panda, N., & Prusty, M. (2020). Effect of urea phosphate foliar supplementation on yield, nutrient uptake and grain quality of rice (Oryza satfva L.) in acid Inceptisols. ORYZA-An International Journal on Rice, 57(2), 132-138.

Noor, S., Yaseen, M., Naveed, M., & Ahmad, R. (2017). Use of controlled release phosphatic fertilizer to improve growth, yield and phosphorus use efficiency of wheat crop. Pak. J. Agri. Sci, 54(4), 541-547.

Ochmian, I., Oszmiański, J., Jaśkiewicz, B., & Szczepanek, M. (2018). Soil and highbush blueberry responses to fertilization with urea phosphate. Folia Horticulturae, 30(2), 295-305.

Ortiz-Monasterio, J., Manske, G., & Van Ginkel, M. (2001). Nitrogen and phosphorus use efficiency. Application of physiology in wheat breeding, 200-207.

Ott, C., & Rechberger, H. (2012). The European phosphorus balance. Resources, Conservation and Recycling, 60, 159-172.

Sattar, B., Ahmad, S., Daur, I., Hussain, M. B., Ali, M., ul Haq, T., . . . Bakhtawer, M. (2021). Bioactive-sulfur coated diammonium phosphate improves nitrogen and phosphorus use efficiency and maize (Zea mays L.) yield. Journal of Environmental and Agricultural Science, 23 (3&4), 23-29.

Shenoy, V., & Kalagudi, G. (2005). Enhancing plant phosphorus use efficiency for sustainable cropping. Biotechnology advances, 23(7-8), 501-513.

Timilsena, Y. P., Adhikari, R., Casey, P., Muster, T., Gill, H., & Adhikari, B. (2015). Enhanced efficiency fertilisers: a review of formulation and nutrient release patterns. Journal of the Science of Food and Agriculture, 95(6), 1131-1142.

Vitousek, P. M., Naylor, R., Crews, T., David, M. B., Drinkwater, L., Holland, E., . . . Matson, P. (2009). Nutrient imbalances in agricultural development. Science, 324(5934), 1519-1520.

Yaseen, M., Aziz, M. Z., Manzoor, A., Naveed, M., Hamid, Y., Noor, S., & Khalid, M. A. (2017). Promoting growth, yield, and phosphorus-use efficiency of crops in maize–wheat cropping system by using polymer-coated diammonium phosphate. Communications in soil science and plant analysis, 48(6), 646-655.

Zafar, M., Abbasi, M. K., & Khaliq, A. (2013). Effect of different phosphorus sources on the growth, yield, energy content and phosphorus utilization efficiency in maize at Rawalakot Azad Jammu and Kashmir, Pakistan. Journal of plant nutrition, 36(12), 1915-1934.

Zaidi, A., Khan, M. S., & Amil, M. (2003). Interactive effect of rhizotrophic microorganisms on yield and nutrient uptake of chickpea (Cicer arietinum L.). European journal of agronomy, 19(1), 15-21.