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Effects of Mono-Ammonium Phosphate and K-Humate Applications on Grain Yield and Phosphorus Uptake Efficiency of Bread Wheat Crop (*Triticum aestivum* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Author AMY designed the study, applied the study, lab analysis, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SG supervised, advised and controlled everything from A to Z and in the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Study was aimed to determine the effect of mono-ammonium phosphate (MAP, $NH_4H_2PO_4$) and K-Humate application on grain yield and grain phosphorus uptake efficiency which applied on Central Anatolian calcareous and basic reaction soil. The research was conducted at Bahri Dağdaş Agricultural Research Institute field in dry conditions during 2018 - 19 to determine the effect of phosphorus doses @ 0, 17.5 and 35.0 kg ha^{-1} and K-Humate @ 0 and 12 kg ha^{-1} on Bayraktar 2000 variety of bread wheat crop grain yield, agronomic (AE), physiological (PE) and apparent recovery (AR) phosphorus uptake efficiency.
Results of the research revealed that increased phosphorus rate, enhances grain yield and amount of grain phosphorus uptake increase, while the grain AE, PE and AR were decreasing significantly. Additionally, with the K-Humate application with respect to control, the grain yield was positively affected in P_0 and $P_{17.5}$, while the grain phosphorus uptake amount was increased by 13%, in the

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P_{35} application the grain yield and the grain phosphorus uptake amount decreased by 9% and 5% respectively. In another direction, with the K-Humate application depending on control, in $P_{17.5}$ application grain AE and AR were increased by 13% and 12% respectively, while grain PE decreased by 54%. Besides, with the K-Humate application according to control and in the P_{35} application grain AE, PE and AR were decreased by 66%, 51% and 40% respectively.

Keywords: Bread wheat; grain phosphorus uptake efficiency; grain yield; K-Humate; phosphorus.

1. INTRODUCTION

Phosphorus deficiency is very common in world agricultural soils [1], besides that, when phosphorus fertilizers applied to the soil, phosphorus uptake efficiencies of plants were observed very low. For this reason, the most nutrient elements consumed as chemical fertilizers after nitrogen in plant production is phosphorus. It is known that reducing the use of phosphorus without decreasing production per person is only possible by increasing the plant phosphorus use efficiencies [2]. Because when added phosphorus to the soil as fertilizers, the soil's pH, lime, organic matter, soluble Ca, Mg, Al, Mn such as 2 and 3 valence cations, clay amount and type, the amount of water in the soil, the temperature and depending on the application method of the fertilizer, the most phosphorus (70 - 90%) is losing by fixation and low diffusion coefficient for that phosphorus uptake efficiency by plants [3] is very low. Thus, a series of many studies have been determined that wheat plant P use efficiency is 8% when the phosphorus applied by using soil surface method while it was 16% when the phosphorus added by the band placement method [4,5]. There are many studies, stated that phosphorus uptake efficiency of plants can be increased by increasing available phosphorus for plants in soil by reducing the fixation of phosphorus in the soil, or by applications of some material that can increase the dissolution and diffusion of phosphorus fixation [6]. In this context, K-Humate is one of the materials which can be used. Bidegain et al. [7] cleared that applied humic substances extracted from mineralized poplar sawdust to soils in which grass plants were grown with very low elevation P to the plant. They are stated that phosphorus uptake and use efficiency of the plant increased as a result of the dissolution of phosphorus, which formed salts with low solubility with divalent cations in the soil. K-Humate as a soil regulator positively affects the activity of microorganisms by adding organic carbon to the soil, by forming complexes with the functional groups, to decrease plant nutrients losses in the soil and plant nutrients uptake was increasing. So it affects the plant root development positively, with the phytohormones released by its breakdown, and it has a positive effect on the growth and plant nutrients uptake [8].

In greenhouse conditions, increasing of mono-ammonium phosphate (MAP) and di-ammonium phosphate (DAP) fertilizers application on slightly alkaline (pH 7.38) soil, Bayraktar 2000 variety of bread wheat (*Triticum aestivum L.*) plant agronomic phosphorus uptake efficiency (AE) and physiological phosphorus uptake efficiency (PE) were decreased significantly, whereas Anti.cin 98 cultivar of popcorn (*Zea mays L.*) plant agronomic phosphorus uptake efficiency (AE) and physiological phosphorus uptake efficiency (PE) were increased significantly [9]. Papadopoulos [10] found that when increased phosphorus applications in the form of mono-ammonium phosphate (MAP), di-ammonium phosphate (DAP) and tri-super phosphate (TSP) phosphorus fertilizers to a calcareous and basic reaction soil, apparent recovery phosphorus use efficiency (AR, %) of the barley plant was decreased significantly. Under greenhouse conditions increasing phosphorus doses application in di-ammonium phosphate (DAP) form to light alkaline soil significantly increase wheat dry matter yield and phosphorus uptake while it was significantly decreasing wheat agronomic phosphorus uptake efficiency (AE) and physiological phosphorus uptake efficiency (PE) [11]. Özaktan [12] referred to under field conditions in neutral (pH = 7.1) soil, humic acid (HUMANICA) applications according to the control while agronomic phosphorus uptake efficiency (AE) and apparent recovery phosphorus use efficiency (AR, %) of common bean (*Phaseolus vulgaris L.*) plant were increasing, physiological phosphorus uptake efficiency (PE) of common bean (*Phaseolus vulgaris L.*) plant decreased. Under field conditions, one trail indicated that increasing of different amounts of phosphorus and K-Humate applications to basic reaction soil, showed that the grain yield and apparent recovery phosphorus use efficiency (AR, %) of maize and sesame plants were increased [13].

This study was conducted in calcareous and basic reaction soil to determine the effects of mono-ammonium phosphate (MAP, P) doses and K-Humate application on the grain yield and the grain phosphorus uptake efficiency (agronomic phosphorus uptake efficiency (AE), physiological phosphorus uptake efficiency (PE) and apparent recovery phosphorus use efficiency (AR, %) of Bayraktar 2000 variety of bread wheat crop under dry field condition.

2. MATERIALS AND METHODS

The trial was carried out during the 2018-2019 vegetation period under dry conditions, in the experimental fields of Bahri Dağdaş International Agricultural Research Institute in Konya province of Turkey. The place was 1016 m above mean sea level where the experiment was conducted. In the growing season between October and July 2018-2019, when the trials were carried out, the lowest temperature value of season (0.49°C) and long term average temperature (00.0°C) were found in January. Additionally, the highest year average season temperature (22.9°C) and long term average temperature (23.6°C) were found in July. Also, the average temperature of season was 12.4°C and the long term temperature was 11.6°C. Between October and July, when the trials were carried out, the long term average of total rainfall was 297.3 mm. According to total rain precipitation, 23.5% (69.8 mm) in October-November, 42.7% (126.9 mm) was in December-March, 27% (80.5 mm) was in April-May and 6.8% (20.1 mm) in June were fallen. The total annual precipitation was 346.8 mm with total rain precipitation, 19.9% (69 mm) in October-November, 52.6% (182.4 mm) in December-March, 12.2% (42.2 mm) in April-May and 15.3% (53.2 mm) in June-July. The distribution of precipitation is very important especially in the region where the experiment was conducted. So rainfall distribution is very well in the wheat plant development period. But, the spike and head formation period it was negatively affected to growth and seed quality, because the total amount of rainfall in April (32 mm) and May (10.2 mm) was only 42.2 mm, which it is so less than the long term total (80.5 mm) of April (38.8 mm) and May (41.7 mm) by 47.6%.

The experiment was carried in a Randomized Complete Block Design (RCBD) in factorial arrangement with two factors and 4 blocks under dry condition. In the study, we need to reveal the influence of increasing phosphorus (0, 17.5 and 35 kg P ha^{-1}) as a mono-ammonium phosphate (MAP $NH_4H_2PO_4$, 12% N and 61% P_2O_5) fertilizer and K-Humate (0 and 12 kg HA ha^{-1}) as TKI-Humas (12% humic (HA) + fulvic acid (FA), 5% Organic matter and 2% K_2O) application on seed yield, yield components, seed phosphorus uptake, and phosphorus uptake efficiencies of Bayraktar 2000 bread wheat variety in 2018-2019 vegetation season, when applied to a calcareous and basic reaction soil in a semi-arid climate zone. In this experiment grain yield, harvest index, 1000 seed weight (g), number of seed per spike, Phosphorus content (%) of flag leaves, the amount of seed phosphorus uptake (kg P ha^{-1}), seed agronomic (PE, kg kg^{-1}), physiological (PE, kg kg^{-1}), and apparent recovery phosphorus uptake efficiency (AR, %) were measured. Besides that, 24 treatments (3 doses of phosphorus, 2 doses K-Humate, one Bayraktar 2000 bread wheat variety, and 4 blocks (3*2*1*4 = 24)) were carried out in this experiment. The soil of the place where the experiment was conducted contains an insufficient level of phosphorus (2.5-8 mg P kg^{-1}) for plants according to the limit values reported by FAO [14]. The soil of the trial site does not contain salinity (171 µS cm^{-1}) problem with basic reaction and loam texture, so it contains too much lime (36%) and moderate organic matter (2.44%). The available Zn amount in the soil of the trial site was not enough (<0.5 mg Zn kg^{-1}) and the other nutrients were sufficient.

One year ago the experimental field was left fallow, and it was made ready for planting by using plough cultivator and rake before planting. Urea (46% N) fertilizer was used as the nitrogen source and 31.2 kg ha^{-1} from total (90.0 kg ha^{-1}) nitrogen was given at sowing time and the remaining part (58.8 N kg ha^{-1}) was given during the tillering season. MAP fertilizer was applied to the seedbed with a 3-5 cm seed drill with nitrogen fertilizer (urea) before planting. TKI-Humas (K-Humate) fertilizer was applied to the soil surface before planting and mixed with a rake to a depth of 0-10 cm. The sowing process was carried out in the first week of November with planting machine of cereal, with 500 seeds per m^2, 5 m long of a plot (4 m at harvest) with 20 cm row spacing, and 6 rows (5 m x 1.2 m = 6.0 m^2). In the trial plots, weed control was carried out using 2-4-D ester pesticide when the weeds had 3-5 leaves.

When the crop reached full maturity period, the crop harvested using the plot combine-harvester and seed weight was weighed by precision balance, and the seed yield per plot and hectare (ton ha^{-1}) were estimated. The harvest index (HI) calculation representing the plot in which 50 plants were selected and dried at 75°C until reached the constant weight and dry weight was estimated. Then, the seed and stem weights were determined by blending the obtained material. The harvest index was calculated using the formula below [15].

Harvest Index (HI) = Grain weight (Only seed from 50 plants) / Total dry weight (whole plants 50)

Also, for a thousand-grain weight (TGW), the product obtained from fifty plants and then 250 seeds were counted and weighed by precision balance, then it multiplies (x) to 4 and determined as g [15]. Grain number per spike estimated by the formula below [15]:

Grain Number per Spike (GNS) = grain number (m^2) / spike number (m^2)

The flag leaves of the plant (taken during the spike period randomly) and plant seed (taken during harvest) after drying and grinding were used to determined phosphorus content (%). Approximately 0.2 g from the dried and grinding flag leaves and seed were separately weighed. Then 5 ml from concentrated HNO_3 and 2 ml from H_2O_2 (30% w/v) were added and dissolved under high pressure (200 PSI) in the microwave device (Cem MARSXpress). To ensure the reliability of the analysis, 1 control and 1 certified reference material (1547a Wheat Flour, 8346 Condition Wheat Flour, 1547 Peach Leaves, NIST) were added to the 40-cell microwave set. The volumes of the dissolved samples were completed to 20 ml with deionized water and filtered. The total amount of phosphorus in the filtration was determined with the ICP-AES (Varian, Vista Axiel Simultaneous) device and the phosphorus content (%) of the flag leaves and seed were calculated. Then the amount of seed phosphorus uptake (kg P ha^{-1}) was revealed. Phosphorus uptake efficiencies of the plant grain (Agronomic (AE) physiological (PE) and apparent recovery (AR) phosphorus uptake efficiencies) according to Noor et al. [16] is calculated depending on the formulas stated below:

Agronomic phosphorus uptake efficiency-AE = {The grain yield obtained by fertilizer application (kg ha^{-1}) - The grain yield obtained without applying fertilizer (kg ha^{-1})} / The amount of P given with fertilizer (kg P ha^{-1}).

Physiological phosphorus uptake efficiency-PE = {The grain yield obtained with fertilizer application (kg ha^{-1}) - The grain yield obtained without fertilizer application (kg ha^{-1})} / {The amount of P taken by the grain with the fertilizer application (kg P ha^{-1}) - The amount of P taken by the grain without fertilizer application (kg P ha^{-1})}.

Apparent recovery phosphorus uptake efficiency-AR = ({The P amount taken by the grains with the fertilizer application (kg P ha-1) - The P amount taken by the grains without fertilizer application (kg P ha^{-1})} / The P amount given by the fertilizer (kg P ha^{-1})) × 100.

3. RESULTS AND DISCUSSION

The result revealed that phosphorus doses and K-Humate application and the interaction of them (P*K-H) were affected significantly (*P<0.01*) on grain yield (ton ha^{-1}) of Bayraktar 2000 bread wheat variety. In addition to, as phosphorus average when phosphorus doses were increasing ($P_{17.5}$ = 17.5 and P_{35} = 35 kg P ha^{-1}) according to control (P_0, 3.19 ton ha^{-1}), the grain yield 11% and 12% respectively were increased significantly and when K-Humate did not apply depending on control (P_0, 3.17 ton ha^{-1}), %10 and %18 respectively were increasing significantly too (Table 1). A similar result, on bread wheat by [17-19], on durum wheat by Peker [20], on barley by Valizadeh et al. [21], on corn by Saeed et al. [22] and on corn and sesame by El-Etr et al. [13] were stated that the plant grain yield increased significantly by increasing phosphorus application to the soil. The effect of the K-Humate application on the grain yield has changed according to the amount of phosphorus application. So, while the K-Humate (K-H_{12}) applied to the soil depend to control (K-H_0), the grain yield was increased significantly by a 1.3% according to the P_0 application, and by a 2.2% according to the $P_{17.5}$ application, but when the P_{35} applied, grain yield was decreased significantly by an 8.8% (Table 1). Under P_0 and $P_{17.5}$ applications as a similar result but as an opposite result in P_{35} application some researchers, El-Etr et al. [13] corn and sesame, Mtua et al. [23] dry common bean, on corn plant by Daur and Bakhashwain [24], Khaneghah et al. [25] and Erdal et al. [26] stated that the plant grain yield was increased significantly with the application of K-Humate according to control in basic reaction soils. Kumar et al. [27] reported that the increase in the

Table 1. Effects of phosphorus (P) and K-Humate (K-H) applications on grain yield (ton ha^{-1}) and harvest index

Parameters	Grain yield (ton ha^{-1})			Harvest index		
Treatments	**K-H$_0$**	**K-H$_{12}$**	**Average**	**K-H$_0$**	**K-H$_{12}$**	**Average**
P_0	3.17 D	3.21 D	3.19 B	0.230 A	0.199 C	0.215 A
$P_{17.5}$	3.49 B	3.57 B	3.53 A	0.203 B C	0.190 C	0.197 B
P_{35}	3.73 A	3.40 C	3.57 A	0.224 A B	0.190 C	0.207 A B
Average	3.47 A	3.39 B	3.43	0.219 a	0.193 b	0.206

Capital letters (A, B) are 1% and small letters (a, b) are 5% signs. Different letters: significantly/like letters: insignificantly

yield of bread wheat was due to synergistic effect of K application on translocation of different nutrients available in soil through K-Humate application. The application of K helps in increasing the yield attributing characters and yield of wheat crop [28].

Results showed that phosphorus amount ($P<0.01$) and K-Humate application ($P<0.05$) beside interaction of them (P*K-H, ($P<0.01$)) had a significant effect on the harvest index. Also, the amount of temperature (17.7°C) and rainfall (10.2 mm) of May month caused great negatives impact on flowering and fertilization. For that, results cleared that harvest index (0.190-0.230) decreased between 46-61% ratios according to the values stated by [29]. In point of, phosphorus as average, the harvest index significantly decreased by increasing phosphorus ($P_{17.5}$ = 17.5 and P_{35} = 35 kg P ha^{-1}) applications depend on control (P_0, 0.215) in 8% and 4% respectively. Additionally, while harvest index was a 0.230 in the control (P_0), phosphorus applications ($P_{17.5}$ and P_{35}) in the status of the non-K-Humate application (K-H$_0$) were decreased significantly at a 12% and a 3% respectively (Table 1). This situation may be caused by the high phosphorus salt and less water in May month (10.2 mm), which were decreased the plant water uptake and relative humidity due to the drought. Thus it led to insufficient flowering, fertilization, and grain filling, for that, affected negatively on harvest index. Dikici [19] found a similar result that increasing rate of phosphorus applications on soil results into significant decrease in the harvest index compared to the control.

The result revealed that thousand-grain weight (g) of bread wheat plant did not showed significant ($P>0.05$) affect by phosphorus doses (P) and K-Humate (K-H) applications and interaction of them (P*K-H). Additionally, results showed that P*K-H interaction was non-significant effects on the thousand-grain weight of bread wheat, which means phosphorus and K-Humate did not change it depending on each other. Besides, it was obtained that according to the P*K-H interaction, thousand-grain weight was ranged between 24.58 and 26.93 g (Table 2). Abass [29] reported that one thousand grain weight of Bayraktar 2000 bread wheat variety under normal growing conditions in Konya is between 45-55 (medium = 50) g. Also, the most important reasons for thousand-grain weight large decreasing, the temperature (17.7°C), and rainfall (10.2 mm) values of May in season experiment, which was caused great negativities on flowering and fertilization.

Results explained that phosphorus amount (1%) and K-Humate application (1%) with the interaction of them (P*K-H, (5%) affected significantly the grain number per spike of the bread wheat plant. In the results, the number of grain per spike was increased significantly by adding 17.5 kg P ha^{-1} from phosphorus to the soil around 9% compared to the control. Additionally, according to K-H$_0$ (0 kg K-H ha^{-1}) K-Humat applications, $P_{17.5}$ and P_{35} phosphorus application compared to no phosphorus application (P_0, 22.2), the number of grain per spike was increased significantly with 17% and 4% respectively (Table 2). Under field conditions, a similar result from Kara [17] stated that the effects of increasing phosphorus application to strong alkaline reaction soil according to the control, the number of grain per spike of Bayraktar 2000 variety was increased significantly. On the contrary similar result, under dry filed condition number of grains per spike of bread wheat decreased significantly when phosphorus doses application was increasing to the light alkali reaction soil [19]. Besides that, when K-Humate (K-H_{12}) applied in the soil, the number of grains per spike was decreased by a 3% with no phosphorus status according to control (K-H_0, 22.2) and it was decreased too by a 10% according to control (K-H_0, 23.8) as an average of K-Humate (Table 2). At that time in field condition, the opposite result was found by Erdem [30] in basic reaction (7.81) soil and by Kara [17] in strong alkaline reaction soil, that the effect of K-Humate application significantly increased the number of the grains per spike of the wheat plant compared to K-Humate application.

While the phosphorus content of flag leaves significantly (*P<0.01*) affected by different doses of phosphorus application and the interaction of phosphorus doses, it had no-significantly (*P>0.05*) affected by K-Humate (K-H) application. Furthermore, according to Jones, Wolf and Mills [31] who reported that the sufficiency limit of phosphorus content (%) of vegetation growth (leaves and stem) maybe ≥0.20%. But our results revealed that the phosphorus content (%) of plant flag leaves in all interactions of phosphorus doses ($P_{17.5}$ ve P_{35}) and K-Humate application treatments in the sufficiency (≥0.20%) limit, expect $P_{17.5}$K-H_0 (%0.19) treatment had insufficiency limit. In terms of phosphorus content (%) of flag leaves, phosphorus applications ($P_{17.5}$ = 17.5 and P_{35} = 35 kg P ha-1) compared to control (P_0, 0.16%) were increased by 25% as phosphorus average. Also, phosphorus content (%) of flag leaves was increased too by 19% and 13% respectively by phosphorus applications ($P_{17.5}$ and P_{35}) compared to control (0.16%) with did not apply K-Humate (K-H0) (Table 2). Similar results were found by Erdal et al. [26] in the field which planted by maize, Akhtar et al. [32] in greenhouse and wheat, Valizadeh et al. [21] barley plant in the field, Irfan et al. [11] wheat plant in the greenhouse, increasing amounts of phosphorus application to the soil, the plant phosphorus (%) content was increased significantly.

Results clearly indicated that amount of grain phosphorus uptake (kg P ha^{-1}) had highly significantly (*P<0.01*) affected by phosphorus doses (P) application, it had no-significantly (*P> 0.05*) affected by K-Humate application and interaction of phosphorus doses and K-Humate application (P*K-H). So, when the amount of grain phosphorus uptake (kg P ha^{-1}) was increasing by phosphorus 17.5 ($P_{17.5}$) and 35 (P_{35}) kg P ha^{-1} application according to control (P_0, 10.97 kg P ha^{-1}) at 30% and 51%, respectively in the status of K-Humate (K-H_0) did not apply, and in the status of phosphorus average, it was increased according to control (11.68 kg P ha^{-1}) at 31% and 39% (Table 2). Additionally, some researchers, Yurtseven [33] corn in the greenhouse, Erdal et al. [26] wheat in the field, Akhtar et al. [32] in the greenhouse, Valizadeh et al. [21] barley in the field and Irfan et al. [11] wheat in greenhouse who were determined that the application of phosphorus amount increasingly in the soil was significantly increased the amount of grain phosphorus uptake (kg P ha^{-1}).

The result showed that different levels of phosphorus (P) and K-Humate (K-H) applications and interaction of them (P*K-H) had highly significantly (*P<0.01*) effects on agronomic phosphorus uptake efficiency (AE, kg kg^{-1}) of the bread wheat plant grains. According to grain AE, 17.5 kg P ha^{-1} ($P_{17.5}$), phosphorus application had higher result than 35 kg P ha^{-1} (P_{35}) phosphorus application by 82% (19.50 kg kg^{-1}) as phosphorus average, 14% (18.29 kg kg^{-1}) without K-Humate and 281% (20.71 kg kg^{-1}) with K-Humate (Table 3). Similarly, some researchers Majeed et al. [18] in the field, and Irfan et al. [11] in the greenhouse who were reported that the AE values of the wheat plant decreased significantly when phosphorus doses applications were increasing in the soil. In greenhouse conditions, Yossif and Gezgin [9] revealed that when the application of phosphorus doses in form of MAP and DAP were increased, AE of the wheat plant decreased as the same result and the AE of the popcorn plant increased as an opposite result. Also, as the opposite to our result, Saeed et al. [22] corn in the field, and Akhtar et al. [32] wheat in greenhouse determined that when the phosphorus amount applications increased to the soil, the AE of the plant was increasing significantly. Besides, when K-Humate (K-H_{12}) was applied according to (K-H_0) control, grain AE increased at 13% (20.71 kg kg^{-1}) in $P_{17.5}$ phosphorus application, so, grain AE decreased at 66% (5.43 kg kg^{-1}) in P_{35} application and 24% (13.07 kg kg^{-1}) as phosphorus average (Table 3). A similar result to $P_{17.5}$ application and opposite result to P_{35} application and phosphorus average found by Özaktan [12] when cleared that the AE of the common bean was increasing significantly when K-Humate application in a neutral soil according to control (K-H_0) under the field condition. The addition of K through K-Humate leads to better nutrient translocation in the different plants parts resulting into better AE [34].

Table 2. Effects of phosphorus (P) and K-Humate (K-H) applications on thousand grain weight (g), number of grains per spike, phosphorus content (%) of plant flag leaves and grain phosphorus uptake (kg P ha^{-1})

Parameters	Thousand grain weight (g)			Number of grains per spike			Phosphorus content of plant flag leaves (%)			Grain phosphorus uptake (kg P ha^{-1})		
Treatments	**K-H$_0$**	**K-H$_{12}$**	**Average**	**K-H$_0$**	**K-H$_{12}$**	**Average**	**K-H$_0$**	**K-H$_{12}$**	**Average**	**K-H$_0$**	**K-H$_{12}$**	**Average**
P_0	26.93 a	24.58 a	25.75 a	22.2 b	21.5 b	21.9 B	0.16 C	0.17 B C	0.16 B	10.97 a	12.39 a	11.68 B
$P_{17.5}$	26.65 a	25.90 a	26.28 a	26.0 a	21.8 b	23.9 A	0.19 A B	0.21 A	0.20 A	14.34 a	16.18 a	15.26 A
P_{35}	25.13 a	24.65 a	24.89 a	23.0 a b	20.9 b	21.9 B	0.21 A	0.20 A	0.20 A	16.64 a	15.79 a	16.22 A
Average	26.23 a	25.04 a	25.64	23.8 A	21.4 B	22.6	0.18 a	0.19 a	0.19	13.98 a	14.79 a	14.38

Capital letters (A, B) are 1% and small letters (a,b) are 5% signs. Different letters: significantly/like letters: insignificantly

Table 3. Effects of Phosphorus (P) and K-Humate (K-H) applications on the grain agronomic phosphorus uptake efficiency (kg kg^{-1}), grain physiology phosphorus uptake efficiency (kg kg^{-1}) and grain apparent recovery phosphorus uptake efficiency (%)

Parameters	Grain agronomic phosphorus uptake efficiency (kg kg^{-1})			Grain physiology phosphorus uptake efficiency (kg kg^{-1})			Grain apparent recovery phosphorus uptake efficiency (%)		
Treatments	**K-H$_0$**	**K-H$_{12}$**	**Average**	**K-H$_0$**	**K-H$_{12}$**	**Average**	**K-H$_0$**	**K-H$_{12}$**	**Average**
P_0	-	-	-	-	-	-	-	-	-
$P_{17.5}$	18.29 AB	20.71 A	19.50 A	309.08 a	143.60 a	226.34 A	19.33 AB	21.69 A	20.51 A
P_{35}	16.00 B	5.43 C	10.71 B	124.41 a	60.37 a	92.39 B	16.25 B	9.75 C	13.00 B
Average	17.14 A	13.07 B	15.11	216.74 A	101.99 B	159.36	17.79 a	15.72 b	16.75

Capital letters (A, B) are 1% and small letters (a,b) are 5% signs. Different letters: significantly/like letters: insignificantly

Despite, the different levels of phosphorus (P) and K-Humate (K-H) application had highly significant (p<0.01) effects on the bread wheat grain physiological phosphorus uptake efficiency (PE, kg kg^{-1}), the interaction of them (P*K-H) had no significantly (p> 0.05) affected on it. In that time, $P_{17.5}$ (17.5 kg P ha^{-1}) phosphorus application according to P_{35} (35 kg P ha^{-1}) phosphorus application was decreased grain PE of Bayraktar 2000 bread wheat variety by 59% (92.39 kg kg^{-1}) as phosphorus average, 60% (124.41 kg kg^{-1}) without K-Humate application and %58 (60.37 kg kg^{-1}) with K-Humate application (Table 3). In another direction, Irfan et al. [11] found that increased phosphorus applications in the soil under the greenhouse condition decreased significantly the PE values of the wheat plant. Under greenhouse conditions, increasing of mono-ammonium phosphate (MAP) and di-ammonium phosphate (DAP) phosphorus form application on slightly alkaline soil, while bread wheat (*Triticum aestivum* L.) PE decreased as the same result, popcorn PE was increasing as the opposite result [9]. Moreover, K-Humate (K-H_{12}) application according to control (K-H_0) decreased the grain PE at 53% (101.99 kg kg^{-1}) as K-Humate average and 54% (143.60 kg kg^{-1}) as $P_{17.5}$ phosphorus application and 51% (60.37 kg kg^{-1}) at P_{35} phosphorus application (Table 3). A similar result was determined by Özaktan [12] who found that humic acid (HUMANICA) application on neutral soil according to control, decreased the PE of a common bean plant under field condition, while Yurtseven [33] stated that different organic material sources applied under greenhouse conditions increased the PE of corn as an opposite result. Kumar et al. [34] reported that addition of K through K-Humate leads to better nutrient translocation in the different plants parts resulting into better PE in wheat crop.

Under dry condition field results explained that phosphorus doses and K-Humate application besides interaction of them (P*K-H) had highly significantly (*P<0.01*) effects on the apparent recovery phosphorus uptake efficiency (AR, %) of bread wheat grains. According to grain AR of Bayraktar 2000 variety, $P_{17.5}$ (17.5 kg P ha^{-1}) phosphorus application had a higher result than P_{35} (35 kg P ha^{-1}) phosphorus application by 19% (19.33%) at without K-Humate application, 122% (21.69%) at with K-Humate application and %58 (20.51%) as phosphorus average (Table 3). Similarly, Papadopoulos [10] found that the AR of barley plants decreased significantly when phosphorus doses applications were increasing in mono-ammonium phosphate (MAP), di-ammonium phosphate (DAP) and triple superphosphate (TSP) forms. Under field conditions, in contrast to our results, El-Etr et al. [13] found that AR of corn and sesame plants were increasing when the phosphorus application increased. Also, K-Humate (K-H_{12}) application according to control (K-H_0) while AR of Bayraktar 2000 variety increased significantly by 12% (21.69%) at $P_{17.5}$ applications, it was decreased significantly by 40% (9.75%) at P_{35} application and 12% (15.72%) as K-Humate average (Table 3). Özaktan [12] stated that the application of humic acid application to neutral soil according to without humic acid (K-H_0) application in the field had significantly increased on AR of a common bean plant, so, while these results had similar to the $P_{17.5}$ phosphorus application result, it had opposed to the P_{35} phosphorus application and K-Humate average results.

4. CONCLUSION

Result indicated that without K-Humate application or as phosphorus average, increased phosphorus application in the form of mono-ammonium phosphate enhanced grain yield and the grain phosphorus uptake under dry field conditions. In addition, the grain yield (*P<0.01*) and the grain phosphorus uptake (*P>0.05*) were increased significantly by K-Humate application compared to control in the P_0 and $P_{17.5}$ (0 and 17.5 kg P ha^{-1}) phosphorus applications or as K-Humate average. At the same time, K-Humate application depend to control while grain AE (*P<0.01*) and AR (*P>0.05*) were increasing at $P_{17.5}$ phosphorus application, it decreased at P_{35} phosphorus application and as K-Humate average. However, as the average of K-Humat application or at $P_{17.5}$ and P_{35} phosphorus applications, the grain PE (*P<0.01*) of the bread wheat plant was decreased. Finally, according to the grain AE and AR, the result showed that K-Humate application depending on the control affected positively (increased) at the $P_{17.5}$ phosphorus application, while it was affected negatively (decreased) on the grain AE and AR at the K-Humate average and P_{35} phosphorus application. In addition to, K-Humate application affected positively (decreased) on the grain PE compared to the control.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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