The effect of zeolite, organic matter, and phosphorus on the growth and yield of wheat (*Triticum aestivum* L.)

Wissam Qahtan Alwan Mohammed Al-Mufarji and Mohammed Jarallah Farhan Dawood
Tikrit University, College of Agriculture, Department of Soil and Water Resources
Email: wa230112pag@st.tu.edu.iq

Abstract
A field experiment was conducted at the Agricultural Research Station of the College of Agriculture, Tikrit University, during the autumn growing season of 2024. The split-split-block design was used, including the use of diammonium phosphate (DAP) fertilizer at four phosphorus levels (0, 50, 100, and 150 kg/ha) (21% phosphorus), zeolite at three levels (0, 2.5, and 5 tons/ha), and organic matter at two levels (0 and 10 tons/ha). Sheep manure was added before planting of agriculture. The soil at the site contained 5% gypsum. The study aimed to evaluate the effect of adding zeolite, organic matter, and phosphorus on some characteristics of wheat plants. The use of zeolite, organic matter, and phosphorus, individually or in combination, resulted in a significant increase in all studied growth characteristics, such as dry weight after 30 and 60 days of planting, chlorophyll, plant length, and the percentage of P% in straw. The application of zeolite (5 tons/ha), organic matter (10 tons/ha), and phosphorus (150 kg/ha) resulted in the highest values for dry weight after 30 days of planting (62.48 g), dry weight after 60 days of planting (120.73 g), chlorophyll (59.70), plant length (103.66 cm), and the percentage of P% in straw (0.27 %) compared to the treatment of zeolite (0), organic matter (0), and phosphorus (0), which gave 22.87 g, 96.86 g, 38.82, 92.33 cm, and 0.07%, respectively.
Keywords. Wheat, zeolite, organic matter, phosphorus

Introduction
Wheat (*Triticum aestivum* L.) is the most important cereal crop throughout the world, belonging to the Poaceae family. Zeolite and organic matter are used to enhance and reclamate saline-affected gypsum soils, especially in dry areas. Zeolite has a major impact on enhancing the chemical and physical characteristics of soils. Zeolite is one of the most prevalent minerals in sedimentary rocks and is mostly formed of aluminium silicates (SiO_4 , AlO_4) with a naturally occurring crystalline structure [20]. Salinity in the soil and a dry environment have a detrimental effect on agricultural output, which in turn affects food security, especially in desert and water-scarce locations. In order to boost the yield of strategic crops, contemporary agricultural techniques and additives like zeolite and organic matter should be used. It is unknown, therefore, how they interact to affect the characteristics of gypsum soils

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and grain production. Because of its high cation exchange capacity, ability to retain water and nutrients through deep penetration, and potential as a chelating agent, natural zeolite is regarded as a desirable soil amendment. The high pH and calcium carbonate content of the calcareous soils found in arid and semi-arid areas, like Iraq, have a detrimental effect on the availability of nutrients. Over 20% of Iraq's land is made up of gypsic soils. These soils, which are mostly found in the Tigris and Euphrates river basins but can also be found in the western desert, stretch from south of Sinjar to southern Iraq [10]. Due to the dissolving of gypsum (CaSO4.2H2O) in the soil solution, which lowers the availability of vital minerals for plant growth, such as phosphorus, these soils have low fertility [8]. This is because the availability of nutrients is impacted by the soil solution becoming saturated with calcium and sulphate ions. One of the biggest issues facing many nations with arid and semi-arid climates, including Iraq, is soil deterioration. Due to their high carbonate concentration and low cation absorption capacity, these soils have a low organic matter content and a poor ability to retain water and neutrons. Among the most phosphorus-deficient soils are those where ion fixing takes place. Research has demonstrated that in gypsum soils, the addition of organic and mineral fertilizers significantly increases dry matter and wheat grain production, which is important for phosphorus interactions in these soils [3]. Because there are few studies on the combined effect of zeolite and organic matter with phosphorus levels in gypsum soils under these conditions and its relationship to crop growth using organic and mineral amendments, and given the economic importance of wheat (*Triticum aestivum*), it is a major global crop used for food, industry, animal feed, and trade, making it essential for food security and the economy; therefore, the use of zeolite, phosphorus, and organic matter is necessary for increasing yield and grain quality. This study was carried out to assess the impact of various phosphorus levels with the addition of organic matter and zeolite on some growth and productivity characteristics of wheat.

Material and Methods

Soil Samples

At a depth of 0 to 30 cm, soil samples were collected from the Tikrit University Soil Department. In order to undertake analyses and studies relating to the research topic and to assess their physical and chemical qualities, the samples were allowed to air dry before being ground and sieved through a sieve with a diameter of 2 mm (Table 1). The method of [9] was used to determine the proportion of gypsum ($CaSO_4.2H_2O$) in soil samples by determining the weight difference when the crystalline water of gypsum is lost by heating, where the soil's gypsum content was 5%.

Table 1. Some physical and chemical properties of field soil

Measurements	Unit	Values
Texture		S-L-C
N	mg kg^{-1}	27.58
P	mg kg^{-1}	7.83
K	mg kg^{-1}	103.16
Na	mmol L^{-1}	1.2
Ca	mmol L^{-1}	1.26
Mg	mmol L^{-1}	0.62
SO4	mmol L^{-1}	1.32
Apparent density	Mica gram kg^{-1}	1.41
pH		7.31
EC	ds m^{-1}	2.45
CaSO4	g kg^{-1}	52.46
CaCO4	g kg^{-1}	52.02
O.M	g kg^{-1}	9.3
CEC	Centimol kg $soil^{-1}$	13.85
Sand	g kg^{-1}	534
Silt	g kg^{-1}	272
Clay	g kg^{-1}	194

Field Experiment

The field experiment was conducted at the Agricultural Research Station, College of Agriculture, Tikrit University. The soil at the site contained 5% gypsum during the autumn growing season of 2024. The experiment was conducted using a split-block design, with a total of 72 experimental units and three replications. The field was divided into plots, each measuring 2 square meters (2 m × 1 m), with a spacing of 0.5 m between plots. The study included the application of diammonium phosphate (DAP) fertilizer at four phosphorus levels (0, 50, 100, and 150 kg/ha) (21% phosphorus), zeolite at three levels (0, 2.5, and 5 tons/ha), and organic matter at two levels (0 and 10 tons/ha). Sheep manure was added before planting. Wheat seeds of the Fayyad variety were sown in rows on 24/11/2024; the harvesting date was 2/6/2025. Ten rows were planted in each plot, with 10 cm between rows and 5 cm between plants, resulting in fifty plants per row. Fertilizer was applied in the rows using the strip fertilization method to a depth of 7.5 cm, then covered with a light layer of soil.

Nitrogen fertilizer was applied at a rate of 260 kg N/ha in the form of urea (46% N) in two applications: the first at planting and the second 35 days after germination. Potassium fertilizer was also applied at a rate of 160 kg N/ha in the form of potassium sulfate (43% N) in two applications, corresponding to the two nitrogen fertilizer applications, as per [5] recommendations. All crop management practices were implemented, including irrigation and weeding. Surface irrigation was used according to the plants' needs. The experimental crop was harvested at full maturity on June 2, 2025. Half a meter of central rows in each experimental unit was used to calculate its components, such as the number of grains per spike, 1000-grain weight, biological weight, plant length, and phosphorus concentration in the grains.

Statistical Analysis

The data were statistically analyzed using the statistical software (SAS) using analysis of variance (ANOVA) using the split-split-block design and the differences between the means were tested at a significance level of (5%) using Duncan's multiple range test [7].

Results and Discussion

Dry weight after 30 days of planting

Table (2) indicates that the effect of zeolite, organic fertilizer, and phosphorus significantly impacted the dry weight after 30 days of planting. The addition of zeolite (5) yielded the highest value (40.01 g) compared to the zeolite (0), which yielded 34.05 g. Organic matter (10) yielded the highest value (40.43 g) compared to organic matter (0), which yielded 33.98 g. The addition of phosphorus (150) achieved the highest value (50.25 g) compared to phosphorus (0), which yielded 26.65 g. The interaction between zeolite (5) and organic matter (10) gave the highest value of dry weight after 30 days of planting (43.96 g) compared to the zeolite (0) and organic matter (0), which yielded 31.77 g. The interaction between zeolite (5) and phosphorus (150) gave the highest value of dry weight after 30 days of planting (53.32 g) compared to zeolite (0) and phosphorus (0), which yielded 24.58 g. The interaction between organic matter (10) and phosphorus (150) gave the highest value of dry weight after 30 days of planting (57.37 g) compared to organic matter (0) and phosphorus (0), which yielded 24.70 g. The triple interaction between zeolite, organic matter, and phosphorus was significantly superior in the treatment that included zeolite (5), organic matter (10), and phosphorus (150), resulting in the highest dry weight value after 30 days of planting (62.48 g) compared to the treatment with zeolite (0), organic matter (0), and phosphorus (0), which yielded 22.87 g.

Dry weight after 60 days of planting

Table (3) indicates that the effect of zeolite, organic fertilizer, and phosphorus significantly impacted the dry weight after 60 days of planting. The addition of zeolite (5) yielded the highest value (110.45 g) compared to the zeolite (0), which yielded 105.84 g. Organic matter (10) yielded the highest value (108.71 g) compared to organic matter (0), which yielded 107.5 g. The addition of phosphorus (150) achieved the highest value (117.16 g) compared to phosphorus (0), which yielded 98.07 g. The interaction between zeolite (5) and organic matter (10) gave the highest value of dry weight after 60 days of planting (110.52 g) compared to zeolite (0) and organic matter (0), which yielded 104.82 g. The interaction between zeolite (5) and phosphorus (150) gave the highest value of dry weight after 60 days of planting (119.06 g) compared to zeolite (0) and phosphorus (0), which yielded 94.45 g. The interaction between organic matter (10) and phosphorus (150) gave the highest value of dry weight after 60 days of planting (118.54 g) compared to organic matter (0) and phosphorus (0), which yielded 100.07 g. As for the triple interaction between zeolite, organic matter, and phosphorus, it was significantly superior in the treatment of zeolite (5), organic matter (10), and phosphorus (150), which gave the highest value of dry weight after 60 days of planting (120.73 g) compared to the treatment of zeolite (0), organic matter (0), and phosphorus (0), which gave 96.86 g.

Chlorophyll

Table (4) indicates that the effect of zeolite, organic fertilizer, and phosphorus significantly impacted the chlorophyll. The addition of zeolite (5) yielded the highest value (52.62) compared to the zeolite (0), which yielded 49.67. Organic matter (10) yielded the highest value (54.33) compared to organic matter (0), which yielded 47.95. The addition of phosphorus (150) achieved the highest value (55.51) compared to phosphorus (0), which yielded 45.25. The interaction between zeolite (5) and organic matter (10) gave the highest value of chlorophyll (56.09) compared to the zeolite (0) and organic matter (0), which yielded 46.81. The interaction between zeolite (5) and phosphorus (150) gave the highest value of chlorophyll (56.32) compared to zeolite (0) and phosphorus (0), which yielded 41.56. The interaction between organic matter (10) and phosphorus (150) gave the highest value of chlorophyll (58.68) compared to organic matter (0) and phosphorus (0), which yielded 41.84. As for the triple interaction between zeolite, organic matter, and phosphorus, it was significantly superior in the treatment of zeolite (5), organic matter (10), and phosphorus (150), which gave the highest value of chlorophyll (59.70) compared to the treatment of zeolite (0), organic matter (0), and phosphorus (0), which gave 38.82.

Plant length

Table (5) indicates that the effect of zeolite, organic fertilizer, and phosphorus significantly impacted the plant length. The addition of zeolite (5) yielded the highest value (101.04 cm) compared to the zeolite (0), which yielded 99.70 cm. Organic matter (10) yielded the highest value (101.97 cm) compared to organic matter (0), which

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yielded 98.83 cm. The addition of phosphorus (150) achieved the highest value (102.33 cm) compared to phosphorus (0), which yielded 97.22 cm. The interaction between zeolite (5) and organic matter (10) gave the highest value of plant length (102.50 cm) compared to the zeolite (0) and organic matter (0), which yielded 98.00 cm. The interaction between zeolite (5) and phosphorus (150) gave the highest value of plant length (102.50 cm) compared to zeolite (0) and phosphorus (0), which yielded 95.33 cm. The interaction between organic matter (10) and phosphorus (150) gave the highest value of plant length (103.44 cm) compared to organic matter (0) and phosphorus (0), which yielded 94.55 cm. As for the triple interaction between zeolite, organic matter, and phosphorus, it was significantly superior in the treatment of zeolite (5), organic matter (10), and phosphorus (150), which gave the highest value of plant length (103.66 cm) compared to the treatment of zeolite (0), organic matter (0), and phosphorus (0), which gave 92.33 cm.

Percentage of P% in straw

Table (6) indicates that the effect of zeolite, organic fertilizer, and phosphorus significantly impacted the percentage of P% in straw. The addition of zeolite (5) yielded the highest value (0.15%) compared to the zeolite (0), which yielded 0.12%. Organic matter (10) yielded the highest value (0.16%) compared to organic matter (0), which yielded 0.11%. The addition of phosphorus (150) achieved the highest value (0.20%) compared to phosphorus (0), which yielded 0.08%. The interaction between zeolite (5) and organic matter (10) gave the highest value of percentage of P% in straw (0.17%) compared to the zeolite (0) and organic matter (0), which yielded 0.10%. The interaction between zeolite (5) and phosphorus (150) gave the highest value of percentage of P% in straw (0.22%) compared to zeolite (0) and phosphorus (0), which yielded 0.08%. The interaction between organic matter (10) and phosphorus (150) gave the highest value of percentage of P% in straw (0.25%) compared to organic matter (0) and phosphorus (0), which yielded 0.07%. As for the triple interaction between zeolite, organic matter, and phosphorus, it was significantly superior in the treatment of zeolite (5), organic matter (10), and phosphorus (150), which gave the highest value of percentage of P% in straw (0.27%) compared to the treatment of zeolite (0), organic matter (0), and phosphorus (0), which gave 0.07%.

[17] demonstrated in their study that the use of zeolite positively impacted wheat growth, increasing plant height and weight. It also significantly improved root characteristics in the wheat crop, such as root length, dry weight, root diameter, and root volume. [24] indicated in their study that adding zeolite to wheat crops affected plant height, grain weight and size, and protein content. [14] found that adding natural zeolite at percentages of 0%, 1%, 2%, 3%, and 4% led to an increase in wheat plant

height to 70.30, 74.42, 82.32, 91.08, and 98.85 cm, respectively. This is attributed to zeolite's role in reducing the rate of nutrient release from both organic and inorganic fertilizers, retaining nutrients, and enabling better nutrient availability during crop growth stages [16]. This is attributed to the effect of natural zeolite on the chlorophyll content in leaves when the main nutrients, namely nitrogen (a key component in chlorophyll formation), phosphorus, and potassium, are available, which play a role in activating numerous enzymes, including those responsible for chlorophyll synthesis; thus, a deficiency in these nutrients leads to the destruction of chloroplasts in the leaf [15]. The organic matter lowers the pH of the soil, which is an important part of the adsorption process, especially in soils with a lot of organic matter [11,19]. Mixing zeolite with solid livestock manure resulted in increased soybean plant growth and improved germination rates, even under water stress conditions. Researchers attributed this growth to the abundance of nitrogen supplied by zeolite and the resulting increase in chlorophyll levels [18]. [4] pointed out that the products of the decomposition of organic matter in the soil, including carbon dioxide, humic acid, and fulvic acid, are important for reducing the soil's reaction degree and increasing phosphorus availability, as some organic compounds coat certain soil particles or iron and aluminum oxides, which decreases these minerals' ability to retain phosphorus.

The importance of phosphorus lies in the early stages of plant life, as phosphorus controls the reactions of photosynthesis and respiration. It also helps break down carbohydrates and other substances, releasing energy for vital plant processes. It was also found that a lack of phosphorus supply to the plant results in a decrease in the formation of sugars, starch, and cellulose. Proper and balanced nutrition with phosphorus leads to the formation and division of cells and an increase in the number of branches of the root system. This aligns with the findings of [1], who, in a field experiment conducted in Pakistan, investigated the effect of different phosphorus levels on wheat yield in two soils of similar texture but different lime content (4% and 19%). Phosphorus was added in the form of triple superphosphate fertilizer at 0, 20, 40, and 80 kg (pH 0, 60, 80, and 40 kg, respectively). The results indicated an increase in plant height and a positive response among the different field crops to the phosphorus levels. This also supports [6] observation that the availability of added phosphorus in the soil decreases over time and that the amount of available phosphorus in the soil is proportional to the level of added phosphorus.

When mixing zeolite with organic matter, zeolite can enhance macronutrients, reduce the rate of nutrient release from both organic and inorganic fertilizers, retain nutrients, and enable better nutrient availability during crop growth stages [16]. [21]

noted an increase in organic carbon and magnesium in zeolite-treated soil, along with increased plant height, diameter, and productivity. [2] demonstrated that mixing zeolite with organic matter reduced soil salinity and sodium levels while simultaneously increasing wheat yield by 37.4% in arid regions. Adding zeolite to the soil proved superior in improving the efficiency of saline soil treatment compared to adding organic fertilizer. Zeolite acts as a beneficial catalyst for reactions occurring within the soil's internal cavities due to its three-dimensional crystalline porosity and molecular permeability properties, which control the reaction rate.

Organic matter plays a crucial role in reducing phosphorus retention by competing with organic acids produced from the decomposition of organic matter for phosphate at adsorption surfaces. It also reduces the role of iron and aluminum oxides through chelation, thereby decreasing their reaction with phosphate. Furthermore, organic matter lowers soil pH, a key factor in adsorption, particularly in soils with high organic matter content [11,19]. Adding zeolite to the soil contributes to the supply of macro and micronutrients and facilitates plant absorption and utilization. This is especially important in arid and semi-arid regions that suffer from water scarcity and a constant lack of nutrients [12]. [23] reported in their study that when zeolite is mixed with chemical fertilizers, there is an increase in the availability of nutrients in the soil, such as phosphorus, nitrogen, calcium, potassium, and magnesium. The addition of zeolite mineral had high selectivity for ammonium and potassium elements and for phosphorus solubility and availability of these elements in the soil; when the mineral was added to it, it led to an increase in plant growth and productivity [13]. [22] indicated a significant increase in potato yield and phosphorus content with increased levels of organic fertilizer application. The interaction between phosphate and balanced organic fertilization has a significant and direct relationship with growth rate and increased production. Zeolite contributes to holding nitrogen in the soil and protecting it from volatilization and leaching, increasing the solubility of phosphates in the soil, and improving their absorption efficiency [20].

Conclusion

The components of wheat, represented by dry weight after 30 and 60 days of planting, chlorophyll, plant length, and the percentage of P% in straw, increased when zeolite (5 tons/ha), organic matter (10 tons/ha), and phosphorus (150 kg/ha) were added separately or in binary and triple combinations.

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Table 2. Effect of different levels of zeolite, organic matter, and phosphorus on dry weight after 30 days of planting (g plant^{-1})

Phosphorus (kg.ha^{-1})	Organic matter (tons.ha^{-1})	Zeolite (tons.ha^{-1})			Organic matter x phosphorus
		0	2.5	5	
0	0	22.87 mn	24.53 mn	26.70 ml	24.70 f
	10	26.30 ml	29.20 ml	30.33 kj	28.61 e
50	0	26.03 kj	31.96 kj	33.70 kj	30.56 e
	10	31.37 hj	33.93 h	36.83 h	34.04 d
100	0	36.37 h	36.50 h	39.70 h	37.52 c
	10	35.67 fg	43.27 f	46.20 de	41.71 b
150	0	41.83 de	43.40 de	44.17 d	43.13 b
	10	52.03 c	57.60 b	62.48 a	57.37 a
Phosphorus (kg.ha^{-1})		Zeolite x phosphorus			Mean of phosphorus
0		24.58 i	26.86 h	28.51 h	26.65 d
50		28.70 h	32.94 g	35.26 f	32.30 c
100		36.02f	39.88 e	42.95 d	39.61 b
150		46.93c	50.50 b	53.32 a	50.25 a
Organic matter (tons.ha^{-1})		Zeolite x organic matter			Mean of organic matter
0		31.77 e	34.09 d	36.06c	33.98 b
10		36.34 c	41.00b	43.96 a	40.43 a
Mean of zeolite		34.05 c	37.54 b	40.01 a	

Table 3. Effect of different levels of zeolite, organic matter, and phosphorus on dry weight after 60 days of planting (g plant^{-1})

Phosphorus (kg.ha^{-1})	Organic matter (tons.ha^{-1})	Zeolite (tons.ha^{-1})			Organic matter x phosphorus
		0	2.5	5	
0	0	96.86 q	100.63 p	102.73p	100.07 f
	10	92.03 o	96.00 o	100.20 n	96.07 e
50	0	104.53 n	106.53m	108.26 ml	106.44 d
	10	103.06 kl	104.96 k	106.26 j	104.76 d
100	0	111.46 j	112.50 ih	113.70 i	112.55c
	10	108.23 gh	110.30 gf	114.30 f	110.94 c

150	0	114.60 de	115.36 d	117.40 d	115.7 b
	10	115.96 c	118.93 b	120.73 a	118.54 a
Phosphorus (kg.ha^{-1})		Zeolite x phosphorus			Mean of phosphorus
0		94.45 l	98.31 k	101.46 j	98.07 d
50		103.80 i	105.75 h	107.26 g	105.60 c
100		109.85 f	111.40 e	114.00 d	111.75 b
150		115.28 c	117.15 b	119.06 a	117.16 a
Organic matter (tons.ha^{-1})		Zeolite x organic matter			Mean of organic matter
0		104.82 e	106.86d	107.55 c	107.5 b
10		108.75 b	110.37 a	110.52 a	108.71 a
Mean of zeolite		105.84 c	108.15 b	110.45 a	

Table 4. Effect of different levels of zeolite, organic matter, and phosphorus on chlorophyll in plants

Phosphorus (kg.ha^{-1})	Organic matter (tons.ha^{-1})	Zeolite (tons.ha^{-1})			Organic matter x phosphorus
		0	2.5	5	
0	0	38.82 l	41.70 k	44.99 j	41.84 f
	10	44.30 j	49.71 i	52.00 i	48.67 e
50	0	47.26 ih	47.89 gh	48.49 gh	47.88 d
	10	51.62 gh	53.03g	55.10 f	53.25 d
100	0	49.27 f	49.78 f	50.14 f	49.73 c
	10	55.64 f	56.90f	57.58e	56.70 c
150	0	51.91 ed	52.17 cd	52.94 cb	52.34 b
	10	58.53 cb	57.81 ab	59.70 a	58.68 a
Phosphorus (kg.ha^{-1})		Zeolite x phosphorus			Mean of phosphorus
0		41.56 j	45.71 i	48.50 h	45.25 d
50		49.44 g	50.46 f	51.79 e	50.56 c
100		52.45 ed	53.34 cd	53.86c	53.21 b
150		55.22 b	54.99 b	56.32 a	55.51 a
Organic matter		Zeolite x organic matter			Mean of

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(tons.ha^{-1})				organic matter
0	46.81 g	47.88 f	49.14 e	47.95 b
10	52.52 c	54.36 b	56.09 a	54.33 a
Mean of zeolite	49.67 c	51.12 b	52.62 a	

Table 5. Effect of different levels of zeolite, organic matter, and phosphorus on plant length (cm)

Phosphorus (kg.ha^{-1})	Organic matter (tons.ha^{-1})	Zeolite (tons.ha^{-1})			Organic matter x phosphorus
		0	2.5	5	
0	0	92.33 j	95.00 i	96.33 i	94.55 f
	10	98.33 hg	100.00 hg	101.33 h	99.88 e
50	0	99.33 h	98.33 fe	100.00 fe	99.22 de
	10	102.33 fe	102.66 fd	102.00 fd	102.33 d
100	0	99.33 cd	101.00 cd	100.66 cd	100.33 c
	10	101.66 cd	102.00 cb	103.00 cb	102.22 b
150	0	101.00 ac	101.33 ab	101.33 ab	101.2 b
	10	103.33 ab	103.33 ab	103.66 a	103.44 a
Phosphorus (kg.ha^{-1})		Zeolite x phosphorus			Mean of phosphorus
0		95.33 f	97.500 e	98.83 d	97.22 c
50		100.83 c	100.50 c	101.00 cb	100.77 b
100		100.50 cb	101.50 abc	101.83 ab	101.27 b
150		102.16 a	102.33 a	102.50 a	102.33 a
Organic matter (tons.ha^{-1})		Zeolite x organic matter			Mean of organic matter
0		98.00 d	98.91 c	99.58 c	98.83 b
10		101.41 b	102.00 ab	102.50 a	101.97 a
Mean of zeolite		99.70 c	100.45 b	101.04 a	

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Table 6. Effect of different levels of zeolite, organic matter, and phosphorus on percentage of P% in straw

Phosphorus ($kg.ha^{-1}$)	Organic matter ($tons.ha^{-1}$)	Zeolite ($tons.ha^{-1}$)			Organic matter x phosphorus
		0	2.5	5	
0	0	0.07 i	0.07 i	0.08 i	0.07 e
	10	0.08 hi	0.09hi	0.08 hi	0.08 de
50	0	0.09 hi	0.09 hi	0.09 hi	0.09 d
	10	0.09 hi	0.12 hi	0.15 h	0.12 c
100	0	0.10 ge	0.13 de	0.15 dc	0.13 c
	10	0.15 dc	0.18 dc	0.19 dc	0.17 b
150	0	0.14 dc	0.16 c	0.18 bc	0.16 b
	10	0.21 b	0.26 a	0.27 a	0.25 a
Phosphorus ($kg.ha^{-1}$)		Zeolite x phosphorus			Mean of phosphorus
0		0.08 f	0.08 f	0.08 ef	0.08 d
50		0.09 ef	0.10 ed	0.12 cd	0.10 c
100		0.13c	0.15 b	0.17 b	0.15 b
150		0.17 b	0.21 a	0.22 a	0.20 a
Organic matter ($tons.ha^{-1}$)		Zeolite x organic matter			Mean of organic matter
0		0.10 d	0.11 dc	0.12 bc	0.11 b
10		0.13 b	0.16 a	0.17 a	0.16 a
Mean of zeolite		0.12 c	0.14 b	0.15 a	

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