

Agro-Physiological Traits of Potato (*Solanum tuberosum* L. cv. Agria) Affected Different Rate of Zeolite and Triple Super Phosphate

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ABSTRACT

The application of zeolite to soils increases cation exchange capacity, and as increases nutrient retention capacity. Imbalanced nutrient management is one of the reasons responsible for low yield of potato in Iran. This study was carried out in research field of Islamic Azad University; Arak Branch at central of Iran to evaluate effect of zeolite particles and phosphorus fertilizer on agro-physiological traits of potato via factorial arrangement based on randomized complete block design with three replications in 2011. The factors included four concentration of zeolite particles (0, 2, 4 and 6 t.ha⁻¹) and three level of triple super phosphate fertilizer (75, 150 and 225 kg.ha⁻¹). Result of analysis of variance indicated effect of different rate of zeolite on all measured traits (instead tuber dry weight) was significant, also chemical phosphorus treatment can affected the mean tuber weight, biomass yield and tuber dry weight significantly. Interaction effect of treatments on mean tuber weight and biomass yield was significant at 5% probability level. The number of stem per plant, mean tuber weight, tuber phosphorus concentration, tuber yield and biomass yield generally improved by increase zeolite rates. Mean of tuber weight, biomass yield and tuber dry weight increased linearly with increasing phosphorus fertilizer rate from 75 to 150 kg.ha⁻¹, the trends of changes in mean of mentioned traits were reduced by high amount of triple super phosphate application (250 kg.ha⁻¹) significantly. Finally according result of this research the highest biomass yield (58 t.ha⁻¹) was achieved by use of 6.0 t.ha⁻¹ zeolite and 150 kg.ha⁻¹ triple super phosphates, therefore, with a lower consumption of phosphate fertilizer (up to 225 kg.ha⁻¹) it can be saved fertilizer without any significant reduction in yield.

Keywords: *Biomass yield, Phosphorus, Tuber dry weight.*

INTRODUCTION

Potato is one of the most important and widely cultivated industrial crops of Iran. However, low use of fertilizers and imbalanced nutrient management are some of the reasons responsible for low yield of potato in Iran. The potato crop requires balanced dose of nitrogen (N), phosphorous (P), potassium (K) and micronutrients for optimum growth and reach to maximum yield (Ghannad *et al.*, 2014). Phosphorus is one of the most important macronutrient that limiting crop plants in most Iranian soils. It is a critical element to provide cellular energy and energy transfer, photosynthesis, respiration, phospholipids and sugars biosynthesis in some crop plants (Marschner and Marschner, 2012). Phosphorus fertilizers are usually applied to all potato fields in Iran. However, little recent research information is available regarding responses of potato to phosphorus fertilizer under Arak conditions. Reduce the chemical fertilizers or improve fertilizer use efficiency nominated by Diaz and Rosenberg (2008) as the most important goal of agricultural systems. Decrease phosphorus application also, was as a key aims in crop production in recent years (Powlson *et al.*, 2008) because of phosphorus fertilizers contains severe amount of heavy metal such as cadmium and arsenic (specially non standard fertilizer), that too dangerous for human health. Achieving sustainable agriculture along with increasing agricultural product and providing community health is a main goal of agricultural researchers. The use of zeolite clinoptilolite in agricultural lands due to increased cation exchange capacity of the soil and its high tendency to absorb and maintain ammonium can play an important role in reducing soil nutrient washing, especially nitrogen (Mumpton, 1999). Zeolite is a particle with huge

surface exchange area that is well for nutrient adsorption by plant root systems (Ramesh *et al.*, 2011). Some studied revealed that the zeolite application in soils is almost new management technique for NPK availability and duration in irrigated farms (Dechassa *et al.*, 2003). Zeolites also are one of the greatest cationic interchangers that their cationic interchange capacity is more than other types of minerals found in soils. The application of zeolites to soils increases cation exchange capacity, and as increases nutrient retention capacity (Ming and Boettinger 2001, Eroglu *et al.*, 2017). Huang and Petrovic (1994) reported that the application of zeolites to soil reduces the leaching of nitrates. In addition, zeolite acts as a slow release fertilizer, giving the plant access to water and nutrients for more times, which results in a significant saving in water use and reducing the amount of fertilizer to be applied (Ming and Boettinger 2001), thus helping to decrease the amount of water used per crop and the contamination of aquifers due to overuse of chemical fertilizers. The related studies indicated effects of zeolite on high exchange ability phosphorus and reducing pollution load of nutritional elements (Ahmed *et al.*, 2010). Pickering *et al.* (2002) reported the zeolite had significant effect on absorption of phosphorus from phosphate rock by sunflower and its indicated importance of zeolite. Ghannad *et al.* (2014) reported the highest tuber yield was obtained from the plants treated with six tons per hectare of zeolite. Also significant increase was obtained in starch content by treated with 6 tons zeolite per hectare. A similar trend was obtained for nutrient content in the tubers. Finally it can be concluded that the nutrient demand of potato plants could be supplied by integration of chemical fer-

tilizers with zeolite as it was the best factor in this study and present a new way for decreasing the chemical inputs as a goal of sustainable agriculture. This research was conducted to investigate the effect of zeolite particles and phosphorus fertilizer on agro-physiological traits of potato in Arak region.

MATERIALS AND METHODS

Field and treatments information

This study was carried out in research field of Islamic Azad University; Arak Branch (49°42' E, 34°5' N and 1757 m above the sea level) at central of Iran to evaluate effect of zeolite particles and phosphorus fertilizer on agro-physiological traits of potato (*Solanum tuberosum* L. cv. Agria) via factorial arrangement based on randomized complete block design with three replications in 2011. The factors included four concentration of zeolite particles (Z_1 : 0, Z_2 : 2, Z_3 : 4 and Z_4 : 6 t.ha⁻¹) and three level of triple super phosphate fertilizer (P_1 : 75, P_2 : 150 and P_3 : 225 kg.ha⁻¹). The soil characteristics of studied field were inserted in table 1.

Table 1. Soil properties of studied field

Soil depth (cm)	0-30
Acidity (pH)	7.70
EC (ds.m ⁻¹)	1.11
Organic carbon (%)	0.87
Phosphorus (ppm)	10.0
potassium (ppm)	220
Nitrogen (ppm)	900
Zinc (ppm)	0.6
Soil texture	Silty clay loam

Farm management

The experimental site was prepared using a conventional method so field was plowed in 1st of June 2011, in the fallow lands area. Potato mother tubers were planted in 10th of June by 6.6 plants per square meter density. Fertilizer was adding in 0-30 cm soil depth at

sowing time (5th June) so before planting 200 kg.ha⁻¹ potassium sulfates (50% K) was added as usual in potato production field (in 0-30 cm soil depth at sowing time 5th June). Urea (45.5 % N) 400 kg.ha⁻¹ was applied after complete emergence and the other half was added 30 days later. Zeolite and triple super were adding in soil at sowing time according to the treatment of fertilizer application. Plant densities were 66000 plants per hectare. Field irrigation was done with using Siphon. The irrigation round was selected every seven days. Weeds and pest control were followed as in commercial fields of potato production. Harvesting was done when maturity was attained.

Traits measure

At harvest time all data were collected from each pot; number of stem per plant, tuber yield, mean of tuber weight, harvest index, biomass yield and tuber phosphorus content. To determine the phosphorus concentration in the Tubers the samples were analyzed by Murphy and Riley (1962).

Statistical analysis

Analysis of variance was done via SAS software (Ver.8) and means were compared by the least significant different (LSD) test at 5% probability level.

RESULT

Number of stem per plant

Number of stem per plant was significantly affected by different rate of Zeolite at 1% probability level, but effect of different rate of triple super phosphate and interaction effect of treatments was not significant (Table 2). Mean comparison result showed in different rate of Zeolite the maximum number of stem per plant (22) was observed in Z_4 and the lowest one (11) was found in Z_1 treatments.

Table 2. Analysis of variance of measured traits affected zeolite and phosphorus treatments

S.O.V	df	Number of stem per plant	Tuber yield	Mean tuber weight	Harvest index	Biomass yield	Tuber phosphorus content	Tuber dry weight
Replication	2	*	*	*	*	*	*	*
Zeolite (Z)	3	**	*	*	*	*	**	ns
Phosphorus (P)	2	ns	ns	*	ns	*	ns	**
Z*P	6	ns	ns	*	ns	*	ns	ns
CV(%)	-	11.51	9.33	7.32	11.76	9.87	6.78	8.35

ns, * and ** are non-significant and significant at 5 and 1% probability levels, respectively.

Evaluation different rate of zeolite indicated a increasing trend in treatments of Z₂ (54.54%), Z₃ (72.72%) and Z₄ (200%) respectively compared to Z₁ treatment (Fig. 1). Madani *et al.* (2009) and Zelalem *et al.* (2009) have pointed similar results in this regard.

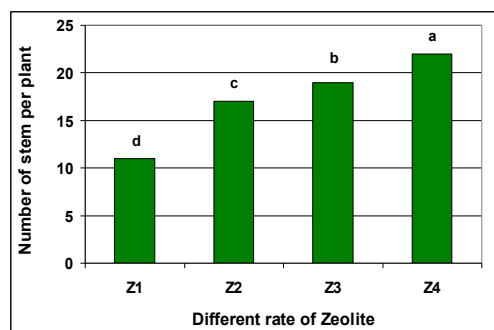


Fig 1. Effect of different rate of zeolite (Z₁=0, Z₂=2, Z₃=4 and Z₄=6 t.ha⁻¹ soil application) on number of stem per plant via LSD test at 5% probability level.

Tuber yield

Assessment result of analysis of variance indicated effect of different rate of Zeolite on tuber yield was significant at 5% probability level, but effect of different rate of triple super phosphate and interaction effect of treatments was not significant (Table 2). According mean comparison result of different rate of Zeolite the minimum tuber yield (34 t.ha⁻¹) was noted for Z₁ and the maximum of that (45 t.ha⁻¹) belonged to Z₄ treatments. Same number of stem per plant trait, Zeolite application (Z₂, Z₃ and Z₄) increased tuber yield by 4.42%, 12.30% and 30.48% respectively compared to Z₁ treatment (Fig. 2).

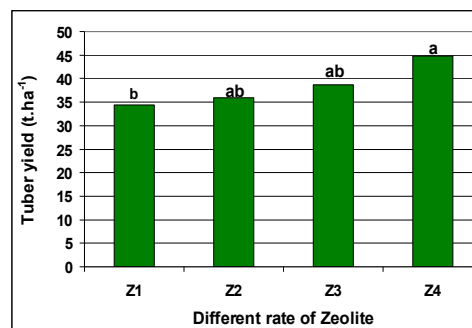


Fig 2. Effect of different rate of zeolite (Z₁=0, Z₂=2, Z₃=4 and Z₄=6 t.ha⁻¹ soil application) on tuber yield via LSD test at 5% probability level.

Plenet *et al.* (2000) reported that phosphorus increased total tuber yield and yield of undersized tubers i.e. less than 85 gr, but decreased the large-sized tubers i.e. greater than 285 gr, several reports indicate that phosphorus has the infective interference in potato crop and biomass accumulation (Madani *et al.*, 2009; Sharmila *et al.*, 2006).

Mean tuber weight

According result of analysis of variance the effect of different rate of Zeolite, triple super phosphate and interaction effect of treatments on mean tuber weight was significant at 5% probability level (Table 2). Mean comparison result revealed that the maximum and minimum amount of mean tuber weight between different rate of Zeolite belonged to Z₄ (96 gr) and Z₂ (71 gr), respectively (Fig. 3).

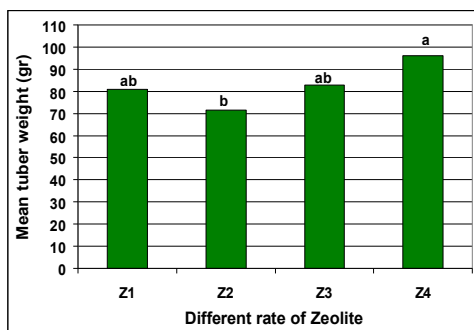


Fig 3. Effect of different rate of zeolite ($Z_1=0$, $Z_2=2$, $Z_3=4$ and $Z_4=6$ $t.ha^{-1}$ soil application) on mean tuber weight via LSD test at 5% probability level.

Also compare different rate of triple super phosphate indicated that maximum mean tuber weight (90 gr) was observed for P_2 and minimum of that (77 gr) was for P_1 treatment (Fig. 4). Assessment interaction effect of treatment showed maximum mean tuber weight (105 gr) was obtained for Z_4P_2 and minimum of that (63 gr) was for Z_2P_1 (Fig. 5). This result was accordance with finding of Ghannad *et al.* (2014).

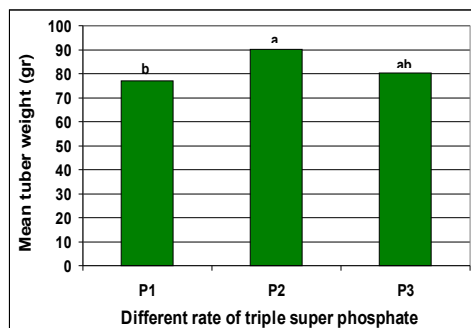


Fig 4. Effect of different rate of triple super phosphate (P_1 : 75, P_2 : 150 and P_3 : 225 $kg.ha^{-1}$) on mean tuber weight via LSD test at 5% probability level.

Harvest index

According to result of analysis of variance different rate of Zeolite had significant effect on harvest index at 5% probability level but effect of different rate of triple super phosphate and inter-

action effect of treatments was not significant (Table 2). Compare different rate of Zeolite revealed maximum amount of harvest index (84%) belonged to Z_4 treatment and there was not significant between another levels of Zeolite treatments (Fig. 6). Khodami Abasiyeh *et al.* (2017) reported same result.

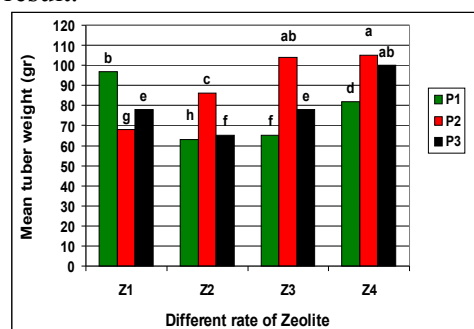


Fig 5. Interaction effect of different rate of zeolite ($Z_1=0$, $Z_2=2$, $Z_3=4$ and $Z_4=6$ $t.ha^{-1}$ soil application) and triple super phosphate (P_1 : 75, P_2 : 150 and P_3 : 225 $kg.ha^{-1}$) on mean tuber weight via LSD test at 5% probability level.

Biomass yield

Result of analysis of variance showed effect of different rate of Zeolite, triple super phosphate and interaction effect of treatments on biomass yield was significant at 5% probability level (Table 2). Evaluation mean comparison result of different rate of Zeolite indicated the maximum biomass yield (54 $t.ha^{-1}$) was noted for Z_4 treatment; there was no significant difference between the other levels (Fig. 7). Also compare different rate of triple super phosphate revealed that maximum biomass yield (58 $t.ha^{-1}$) was observed for P_2 treatment; there was no significant difference between the other levels (Fig. 8). According result of mean comparison of interaction effect of treatments maximum biomass yield (59 $t.ha^{-1}$) was obtained for Z_4P_2 and minimum of that (42 $t.ha^{-1}$) was for Z_1P_3 (Fig. 9).

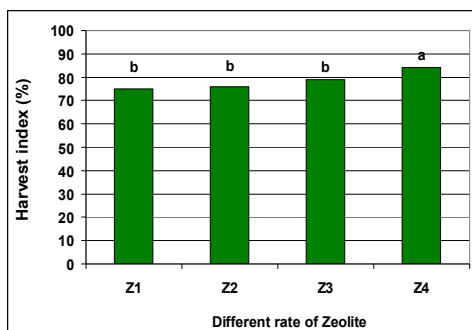


Fig 6. Effect of different rate of zeolite ($Z_1=0$, $Z_2=2$, $Z_3=4$ and $Z_4=6$ t.ha⁻¹ soil application) on harvest index via LSD test at 5% probability level.

Aghaalikhani *et al.* (2012) and Sharmila *et al.* (2006) confirmed mentioned result.

Tuber phosphorus content

Evaluation result of analysis of variance revealed effect of different rate of Zeolite on tuber phosphorus content was significant at 1% probability level, but effect of different rate of triple super phosphate and interaction effect of treatments did not have significant effect on mentioned trait (Table 2).

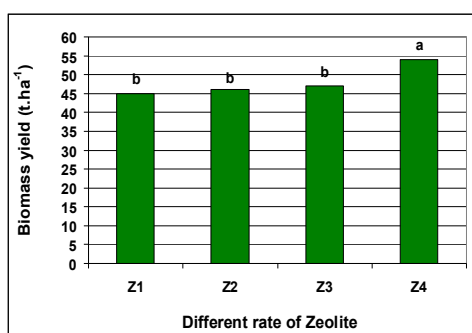


Fig 7. Effect of different rate of zeolite ($Z_1=0$, $Z_2=2$, $Z_3=4$ and $Z_4=6$ t.ha⁻¹ soil application) on biomass yield via LSD test at 5% probability level.

Mean comparison result of different rate of Zeolite showed that the maximum and the minimum amount of tuber phosphorus content belonged to Z_4 (0.17%) and Z_1 (0.13%) (Fig. 10).

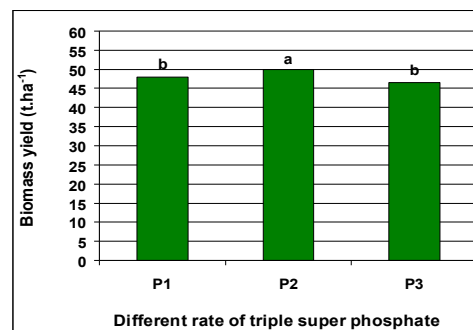


Fig 8. Effect of different rate of triple super phosphate (P_1 : 75, P_2 : 150 and P_3 : 225 kg.ha⁻¹) on biomass yield via LSD test at 5% probability level.

This result was accordance with finding of Ghannad *et al.* (2014).

Tuber dry weight

According to result of analysis of variance different rate of triple super phosphate had significant effect on tuber dry weight at 5% probability level but effect of different rate of Zeolite and interaction effect of treatments was not significant (Table 2). Compare the highest value of tuber dry weight was belonged to the P_2 treatment (22.80%) but there was no significant difference between the other levels (Fig. 11). Imas and Bansal (1999) and Madani *et al.* (2009) reported same result.

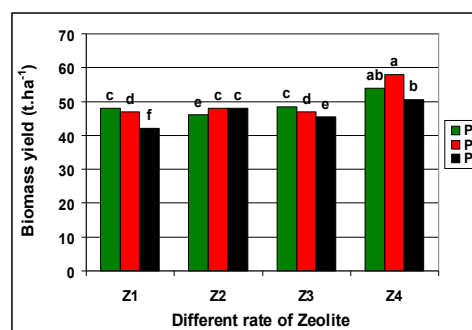


Fig 9. Interaction effect of different rate of zeolite ($Z_1=0$, $Z_2=2$, $Z_3=4$ and $Z_4=6$ t.ha⁻¹ soil application) and triple super phosphate (P_1 : 75, P_2 : 150 and P_3 : 225 kg.ha⁻¹) on biomass yield via LSD test at 5% probability level.

DISCUSSION

Application zeolite treatments significantly influenced on all measured traits in current study (instead tuber dry weight). Phosphorus accumulation in potato tubers increased from 0.13 to 0.17% by zeolite application (2, 4 and $t.ha^{-1}$). So, it seems the available phosphorus in soil increased with Zeolite levels. High amounts of zeolite application ($6 t.ha^{-1}$) in soil could significantly increase the biomass yield ($54 t.ha^{-1}$) and tuber yield ($45 t.ha^{-1}$). In addition, zeolite treatments affected the harvest index from 75 to 84% ($p < 0.05$). Phosphorus fertilization rates had significant effects on mean of tuber weight, biomass yield and tuber dry weight in potato.

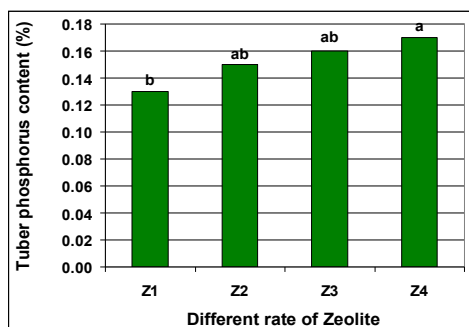


Fig 10. Effect of different rate of zeolite ($Z_1=0$, $Z_2=2$, $Z_3=4$ and $Z_4=6 t.ha^{-1}$ soil application) on tuber phosphorus content via LSD test at 5% probability level.

In current study increasing the phosphorus rates from 0 to $150 kg.ha^{-1}$ cause's increase mean of tuber weight, biomass yield and tuber dry weight parameters and in the more phosphorus application amount from 150 to $225 kg.ha^{-1}$ triple super phosphate can't increase the rhythms of potato responses to more phosphorus availability. In this regard Ghannad *et al.* (2014) reported application of $6 t.ha^{-1}$ zeolite led to maximum accumulate of phosphorus (32.44 %) in potato tuber.

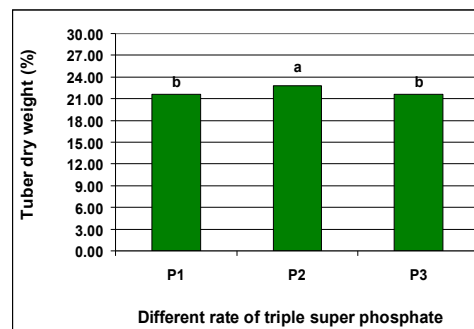


Fig 11. Effect of different rate of triple super phosphate ($P_1: 75$, $P_2: 150$ and $P_3: 225 kg.ha^{-1}$) on tuber dry weight via LSD test at 5% probability level.

CONCLUSION

Finally according result of this research highest biomass yield ($58 t.ha^{-1}$) was achieved by use of $6.0 t.ha^{-1}$ zeolite and $150 kg.ha^{-1}$ triple super phosphates, therefore, with a lower consumption of phosphate fertilizer (up to $225 kg.ha^{-1}$) it can be saved fertilizer without any significant reduction in yield.

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