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Research Article

EVALUATION OF APPROPRIATE TECHNIQUE TO IMPROVE SOIL CHARACTERISTICS AND CROP PRODUCTION

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ABSTRACT
Continuous availability of water is considered as one of the most crucial factors prompting plant growth. The moisture absorbent material can be effective tools in improving water holding capacity. Pumice, which is a moisture absorbent material, can be used to improve soil physical conditions. To estimate water absorption by super absorbent (pumice) and to evaluate the effect of its application on physico-chemical properties of sandy loam soil and yield of maize, laboratory and green house studies were established in 2009 and 2010 at Agriculture Research Center of Eastern Azerbaijan, Iran. In the laboratory study, to determine the value of water absorption 1g of Pumice was set in 1000 ml beaker and the pumice was weighed after 20, 40, 60, 80, 100, and 120 minutes. Based on the results, water absorption increased by increasing time, as water content absorbed ranged from 35 (in 20 minute) until 90 (in 120 minutes) times their weight. Results indicated that absorption improved with time which ranged from 35-90 times their weight over 20-120 minutes. Different pumice treatments (0.10, 0.20 and 0.30 %), corresponding to 1.2, 2.4 and 3.6 g kg-1, respectively were applied in a greenhouse experiment and pumice levels were uniformly mixed with soil. Pots were filled with twelve kg of soil. The results showed that moisture content increased remarkably in treatments containing pumice compared to control. Results, also, revealed that physical properties of the soil were considerably affected by addition of pumice. Saturation percentage increased significantly and was greater 24% than control. Also, Particle density and bulk density were decreased by application of pumice (14-47% and 16-40%, respectively). Moreover, pumice had no effect on the pH and electrical conductivity of the soil. Additionally, maize yield was significantly increased with increasing amount of Pumice. Maximum grain yield was founded with 30% Pumice application (D treatment) which followed by C, B, and control, respectively.

Key Words: *Maize (Zea Mays L.), Pumice (Superabsorbent Material), Moisture, Environmental Stress*

INTRODUCTION
Plants in natural and agricultural conditions are often faced to environmental strains. Some factors such as soil water content can be demanding after a short time. Iran is located on a dry climate with very hot summer and cold winter (FAO, 1997). According to Mazaheri and Mjnoun-hosseini (2005) about 10 percent of the Iran's areas have more than 500 mm of rainfall over the years and the rest have to be watered for the plants growth. Iran, then, according to geographical location and topographic conditions, has always been faced with drought during the last centuries (Moazzen-Ghamsari *et al.*, 2009). Hayat and Ali (2004) reported that moisture stress is a restrictive factor for crop production in arid and semi-arid regions because of low and uncertainty rainfall. Crop production is largely dependent on ecological and soil conditions.
Maize (*Zea mays* L.) is one of most important crop that plays a key role in human nutrition (20-25%) (Emam, 2004). Water deficiency is a serious problem limiting maize growth through effects on anatomical, morphological, physiological and biochemical processes. Setter *et al.*, (2001) found that the severity of drought damage depends on stress duration and crop growth stage. The limited water resources to increase agricultural efficiency joined to low rainfall and high evapotranspiration, which most plants do

not have the ability to resist or poorly grow albeit it can be tolerated, emphasize the need to access different tools to soil moisture retention for crop growth, development and yield.

In many cases problems can be resolved using water absorbent. Super absorbent materials (SAMs) are hydrophilic polymer complexes that have potential to absorb large volumes of aqueous fluids within a short time and under stress conditions can hold the absorbed water. Pumice is one of the super absorbents, being a type of extrusive volcanic rock, produced when lava with a very high content of water and gases is extruded from a volcano and serves to open up the mix and reduce the moisture retention properties of the soil (Akbal, 2004). The application of super absorbent polymer has a significant impact in reducing drought stress effects and to improve plants yield and stability in agriculture production (Khadem et al., 2010). Woodhouse and Johnson (1991) showed that hydro-absorbents can play a crucial role in germination rates because of improving water accessibility. Fruit quality was better using polymers in the growing media as water stress reduced during the growth cycle (Johnson and Piper, 1997). According to Johnson (1984) application of hydrogel at the rate of 2 g/kg increased the water holding potential of sand from 171% to 402%. The objective of the present study was to determine the effects of pumice on water retention in soil and on maize growth characteristics.

MATERIALS AND METHODS

These experiments were included Laboratory and green house studies which were conducted during 2009 and 2010 at Agriculture Research Center of Eastern Azerbaijan, Iran.

Estimation of Pumice moisture content (Laboratory studies)

To estimate the amount of absorbed water by pumice a weighed quantity (1g) of this super absorbent was placed in a beaker contains 1000 ml and weight of pumice was measured after 20, 40, 60, 80, 100 and 120 minutes.

Evaluation of moisture content of soil (Green House Experiment)

The soil was a clay loam. The experiment was laid out in completely randomized design with four replications. Soil samples collected from farmer's field of desired district were air-dried, thoroughly mixed and passed through 2-mm sieve. Physical and chemical characteristics of the soil are shown in Table 1. For this experiment, 32 pots were used and each pot was filled with 12 kg of soil.

A) Control (without Pumice); B) 0.10% Pumice (1.2 g kg^{-1}); C) 0.20% Pumice (2.4 g kg^{-1}) and D) 0.30% Pumice (3.6 g kg^{-1}).

Planting and Irrigation Conditions

To improve soil fertility, before planting, diammonium phosphate (18-46-0 N-P-K) and urea were applied at the rate of 250 and 150 kg ha^{-1}, respectively. At maize 6-8 leaf stage, 200 kg ha^{-1} N (as urea) was added. Pots were saturated with tap water before planting/transplanting the seedling and excess water was drained from the bottom of the pot. The maize hybrid “Singles Cross 704” was planted on May 4 in both years (2009-2010). Two seeds were planted in each pot for plant growth and then thinned to the target densities (1 plant per pot) after their establishment. Pots were irrigated soon after planting. Irrigation also was done every 24 hours until seed germination. Moreover, the plants were watered only when they showed signs of water shortage.

Soil Moisture Contents

To determine moisture, soil samples were periodically gathered with a tube soil sampler before the next irrigation. The moisture percentage was measured using gravimetric method.

Yield and Yield Components

The fresh and senesced leaves (i.e. yellowed and dead leaf tissues still attached to the plant) of maize were separated, and the leaf area of fresh leaves was measured with a Delta England leaf-area meter (Delta-T Devices, Cambridge, England). At physiological maturity, maize plants of different treatments were harvested. The harvest was transferred to the laboratory and height, stem diameter, 1000-seed weight (One hundred grains were counted and weighed, and the result was converted to 1000-grain weight) and grain yield of maize in each treatment were determined. (Gharibzahedi et al., 2011b).

Statistical Analysis

All data were initially subject to ANOVA using the GLM procedure of SAS (SAS Institute, 2002). Treatment means were separated using LSD test at $P < 0.05$.

Table 1: Physical and chemical characteristics of soil and Pumice used for the study

Soil characteristic	Value*	Pumice characteristic	Value*
Texture	Clay loam	Color	Light gray/Tan
Soil depth (cm)	25.0±5.0	Toxics	No
Saturation (%)	1.39±0.02	Water soluble	A little
EC(ds m^{-1})	3.30±0.04	Humidity (%)	3.40±0.05
pH	7.82±0.01	Density (g/ml)	0.951±0.004
OC	0.65±0.02	pH	7.30±0.06
P (ppm)	8.20±0.05	Dimension (mm)	15.0±10.0
K (ppm)	340.0±16.0	-	-
N (%)	0.07±0.00	-	-

** (No. of observations = 3)*

RESULTS AND DISCUSSION

Saturation Percentage

As found from the Saturation percentage rates obtained of clay loam soil under different treatments, the saturation percentage raised by the application of Pumice and the soils treated with different value of pumice showed higher rate of Saturation percentage compared to untreated soil (table 3). The uppermost rate of saturation percentage (25.42%) was observed in soil included 0.30% of Pumice which was considerably upper than other treatments. The previous studies verified that soil physical condition and soil water retention was advanced by superabsorbent polymer (Khadem et al, 2010).

Bulk Density

Result showed that Bulk density content decreased by increasing pumice levels (Table 3). Maximum value of bulk density (2.3 Mg m^{-3}) was related to in the untreated soil. Hayat and Ali (2004) reported that bulk density was reduced by application of Aquasorb. According to study of Wallace and Wallace (1986) the polymers improved the soil characteristics. They found that low levels of polymer application induced very little improvement compared with high ones.

Particle Density

Particle density was decreased by application of pumice values (table 3). The highest (2.87) and lowest (1.7) value of particle density were created in the untreated soil and 30% pumice application, respectively. Among the different levels of pumice applied 30% pumice application (1.7) produce better result which was followed by 20% pumice (1.85), 10% pumice (2.4), respectively. Our results are concurrence with previous results (Hayat and Ali 2004) based on decreasing of particle density with application of super absorbent in soil.

pH and EC of Soil

The results pointed out that pH were not affected under different level of pumice (Table 3). Data from EC rates of the soil showed that there were not significantly different among the various treatments, even though EC was decreased by increasing pumice levels (Table 3).

Soil Nutrient Contents

Based on results provided, different amount of pumice were not significant on nitrate-N, phosphorus, and total organic carbon (TOC) of clay loam soil (Table 4). Potassium was the only Nutrient affected by different levels of pumice and its content was increased by increasing pumice levels. The highest and lowest K content were provided in 30% pumice application and the untreated soil treatments, respectively (table 4). Apparently, pumice increased the nutritional supply through enhancing moisture retention

Table 3: Influence of different treatments of Pumice on some physico-chemical characteristics of clay loam soil after the harvest of maize

Treatments	Saturation percentage	Bulk density (gcm-3)	Particle density (gcm-3)	pHs	ECe (dSm-1)
A Control (No Pumice)	22.35[a]	2.3[a]	2.87[a]	7.3[a]	4.7[a]
B 0.10% Pumice (1.2 g kg^{-1})	24.42[b]	1.96[b]	2.4[b]	7.35[a]	4.4[a]
C 0.20% Pumice (2.4 g kg^{-1})	26[c]	1.5[c]	1.85[c]	7.36[a]	4.3[a]
D 0.30% Pumice (3.6 g kg^{-1})	27.8[d]	1.2[d]	1.7[d]	7.3[a]	4.1[a]
LSD	0.149	0.006	2.543	1.45	0.008

**Means within each column sharing the same letter(s) are not significantly different based on LSD test at p = 0.05.*

Table 4: Influence of different rates of pumice on nutrient contents of the clay loam soil after the harvest of maize

Treatments	NO3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})	TOC* (%)
A Control (No Pumice)	7.1[a]	6.76[a]	345[d]	0.73[a]
B 0.10% Pumice (1.2 g kg^{-1})	7.00[a]	6.87[a]	354[c]	0.76[a]
C 0.20% Pumice (2.4 g kg^{-1})	7.1[a]	6.92[a]	378[b]	0.79[a]
D 0.30% Pumice (3.6 g kg^{-1})	6.95[a]	7.2[a]	411[a]	0.81[a]
LSD	0.23	0.006	2.543	1.45

**TOC = Total organic carbon*
**Means within each column sharing the same letter(s) are not significantly different based on LSD test at p = 0.05.*

Grain Yield

The results of ANOVA for the effects of different treatments of pumice on maize grain yield are summarized in Table 2. As shown, seed yield was significantly affected by different amounts of pumice. According to the results, the seed yields of maize increased with increasing amounts of pumice. The highest (4.1 ton ha^{-1}) and lowest (3.8 ton ha^{-1}) maize grain yield were found with 0.30% pumice application and control plants, respectively (Table 3). This can probably be attributed to the higher emergence and better crop establishment as a result of moisture supply (Bhardwaj et al., 2007; Gharibzahedi et al., 2011a). Hayat and Ali (2004) also found that absorption of water by synthetic polymer and its effect on yield parameters helps to increase the yield of crops. Increasing in corn yield by application of super absorbent polymer was previously reported by Khadem et al. (2010). Rehman et al. (2011) observed use of hydrogel significantly increased the kernel yield of rice (2.39 ton ha^{-1}) as compared to no hydrogel (2.25 ton ha^{-1}). Moreover, Johnson and Piper (1997) demonstrated that the application of polymers to growing media due to the reduced impact of water stress during the growing cycle can improve crop quality.

Table 5: *Mean values of different treatment of Pumice on yield of maize*

Treatments	Yield (ton ha^{-1})
A Control (No Pumice)	3.80 ± 0.02^{c}
B 0.10% Pumice (1.2 g kg^{-1})	3.83 ± 0.08^{c}
C 0.20% Pumice (2.4 g kg^{-1})	3.95 ± 0.03^{b}
D 0.30% Pumice (3.6 g kg^{-1})	4.11 ± 0.18^{a}
LSD	0.08

Conclusion

The present research approved that pumice can plays an significant role in the keep of soil moisture, due to changes in soil particles distribution and liquid and gas phases by adding water which increases the proportion of liquid compared to gas.

Management practices and applying advanced techniques to maintain soil moisture storage and increasing water-holding capacity of soil are critical to increase irrigation efficiency and thus improve the utilization of limited water resources in the country. Using pumice material is a new method to achieve the above mentioned purposes. Pumice is extracted by mining companies in Iran and it can be obtained for a reasonable price; however, it normally is expensive. Pumice increases irrigation period approximately 2-fold in dry areas; so, it can be expected that irrigation costs decrease by half therefore economically justify its use.

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