The Interaction of Organic Fertilizer and Pitting on Nutrient Content, Phenolic Compounds, and Root and Shoot Lengths in Vetiver Grass (*Chrysopogon zizanioides* L.)

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Abstract

The shortage of elements in the soil and water available to the plant are some of the most common environmental stresses in Iran which faces drought every year. The purpose of this study was to study the effect of pitting and organic fertilizers on the growth and physiological characteristics of vetiver grass in drought stress conditions. After cultivating the seedlings in the pots in the greenhouse and their growth for 3 months, the seedlings were transformed to the field and the treatments were applied to them for 6 months. This experiment was conducted as a factorial experiment based on randomized complete block design in the field. The treatments applied to the seedlings were cultivation with pitting and without pitting, three levels of fertilizer (0, 150, and 300 kg fertilizer per hectare), and two levels of irrigation (FC and 1/4FC). After harvest, the plants were transferred to the laboratory for measurements. The magnesium element was extracted and measured by atomic absorption spectrometry, potassium by flame photometric method, phosphorus and phenol by absorption method in the optical spectrum, and calcium by titration method. The results showed that by applying pitting and fertilizers, shoot height changed from 9.8 cm to 16.68 cm, root length from 18.81 cm to 25.55 cm, potassium from 25.95 mg/kg to 34.30 mg/kg, calcium from 1.20 mg/kg in pitting treatment to 2.27 mg/kg in non-pitting treatment, phenol from 0.22 mg/g DW to 0.83 mg/g DW and phosphorus from 2.99 mg/kg to 11.95 mg/kg.

Keywords: Drought stress, Physiological characteristics, Field capacity, Shoot Length

Introduction

Plants are exposed to various stresses during their growth period. In the meantime, water scarcity is the biggest challenge in crop production especially in arid and semi-arid regions including Iran (Munns, 2002; Lashkari et al., 2021). Lack of rainfall causes salinity and alkalinity of the soil (Malekzadeh Shamsabad et al., 2021). Rainfall The effect of water stress depends on its duration and the amount of its deficiency (Pandey et al., 2001). The identification of the critical time and irrigation scheduling based on a detailed and fundamental plan for the plant is a key to maintaining water and improving irrigation and plant tolerance to water shortages in agriculture (Babaei et al., 2010). The main cause of water stress in the plant is the increase in water loss, or the lack of water absorption, or a combination of both of these factors, by which the amount of water loss due to transpiration exceeds its absorption by the roots and the stress level increases (Haajabi et al., 2005). One of the most important factors limiting the production of crops in arid and semi-arid regions is the water shortage stress in the growth stages (Harrison et al., 2014). Vetiver as permanent bunch grass has tall stems and roots (Truong et al., 2008). Vetiver Grass is herbaceous, perennial, and evergreen plant which has a high tolerance to drought stress (Akhzari et al., 2018).

In water constraint conditions, sufficient growth and root productivity are essential for crop productivity (Alizadeh et al., 2015). As an important vegetative organ, roots provide water and mineral resources necessary for plant growth. Roots are not visible which has caused them not to be considered in many cases despite their vital role (Eric and Robert, 2007). Water is essential for growth as testified by the fact that roots do not grow in dry layers.

Roots are completely connected to the aerial parts of the plant. The ratio of roots to the aerial parts of the plant is always commensurate. The physiological characteristics of plants in water absorption are considered to be more important in their adaptation to dehydration due to lack of moisture in the soil than root density in different layers. It has been stated that during water stress in surface layers, the roots in the depths absorb water more efficiently. Ellis and Barnes (1980) said that the drier the soil, the less the weight of the roots. This regulates through the production of more organic matter such as protein, soluble sugars (Rampino et al., 2006), and amino acids (Showler and Castro, 2010) in the air and root organs The research results showed that in areas with heavy texture and marl, furrow pitting can be used which not only preserves rainfalls and protects soil, but also creates a suitable vegetation cover (Habibzadeh et al., 2007). In a study on fennel (*Foenicudum vulgar Mill.*), it was demonstrated that the use of organic fertilizers and manure increased the growth of plant (Tavali, 2021), number of seeds in the plant (Moradi, 2009). In this study, the reason for this increase was the improvement in the nutritional status of the plant as well as the increase in water available to the plant due to soil physical improvement. The results of the research by Arun et al. (2002) showed that organic fertilizers improved the physical, chemical, and biological properties of the soil and increased the yield of the product. A study also reported that by increasing the amount of manure from 10 to 20 tons per hectare, the number of seeds in the green bean plant (*Phaseolus vulgar L)* increased from 140 to 178 (Gomma and Mohamed, 2007). In order to evaluate the effect of chemical, organic, combined, and biologically active chitosan fertilizers on phenolic content, antioxidant activity, and physiological properties of the medicinal plant *Thymus deanensis Celak*, an experiment was designed whose results showed that the interaction of fertilizer and chitosan levels on leaf area index and total dry matter became significant (Emami Bistgani et al., 2015). Chamani et al. (2011) studied the effects of applying pitting and contour furrow methods on vegetation deployment in Golestan ranges in 2011. They concluded that using the contour furrow method has a greater effect on vegetation than the other methods.

Materials and methods

The greenhouse and field in which the cultivations were carried out and the treatments were applied are located at Malayer University and Farm, and in a pilot area in Malayer located in the southeast of Hamadan province. Geographical coordinates are located in the longitude "1 51 ° 48 'and' 56 '15 ° 34' latitude. Based on the data of the Malayer synoptic meteorological station, the annual temperature of the area is +45. 13 centigrade, which changes from 4.2 to +28 centigrade in the winter and summer seasons. The coldest month of the year is (0.08° C) and the warmest is the beam (26.74 degrees). The average precipitation in the region is 323.1 mm per year. The highest mean monthly rainfall was in March with a mean of 58.5 mm and the lowest was in September of the month with a 1.2 mm magnitude (Fattahi et al, 2018).

Analysis method

In order to study the effects of organic fertilizers and the role of pitting on the establishment and physiological and morphological characteristics of vetiver grass, an experiment was conducted as a completely randomized block design. To apply drought stress, two levels of irrigation (FC and 1/4 FC) with 4 replications were done while manure was applied at the levels of 0, 150, and 300 kg per hectare with 4 repetitions. The seedlings were taken to the greenhouse environment and the soil used for cultivation was poured into the pots after being passed through a 2 mm sieve. In each pot, one seedling was planted. Then after cultivation, all the 128 pots were irrigated equally and completely and were put at room temperature in the natural light of the greenhouse and were irrigated by the amount mentioned above twice a week under the same conditions. About 3 months later, when the seedling became green and grew enough, the pots were moved from the greenhouse to the field and planted in the land. The mechanical operations of pitting and normal planting were done and then fertilization and drought stress treatments were applied to the seedlings. Six months after the application of the treatments and the complete fixation and establishment of the plants, they were transferred from the field to the laboratory for testing.

Data analysis

All analyses were performed with SAS software.

Results

The results showed that statistically pitting, organic fertilizer, and irrigation had a significant effect on the shoot height of the plant (P <5%). Field capacity irrigation and the application of manure increased shoot height. This increase was higher using pitting than conventional cultivation (Figure 1).

It was observed that pitting caused an increase in root length in the treatments. Different levels of fertilizer also had a significant effect on root length (Figure 2).

Potassium had a higher concentration in the plant in the pitting treatment than the non-pitting treatment (P <5%). This difference is more pronounced in the 100 kg fertilizer treatment (Figure 3).

It was observed that pitting had a negative effect on the concentration of calcium and reduced it. However, in conventional cultivation, the amount of calcium significantly increased. Also, with the increase of fertilizer amounts in conventional cultivation, calcium concentration increased (Figure 4).

It was generally observed that pitting increased phenol and its concentration in the plant (P <5%). Except for one case (conventional cultivation with the application of 500 kg fertilizer and 1/2 field capacity irrigation), phenol increased significantly in the field (Figure 5).

In the case of phosphorus and its concentration, it was observed that there was no difference between conventional cultivation and pitting and different levels of fertilizer had no significant effect on phosphorus concentration.

Discussion

Increase in the height of the shoot may be related to management factors, including the direct effect of the amount of water on the growth of the seedlings. In this way, with the increase of water in the hole in the pitting treatment, the shoot heights of the seedlings were increased.

Calcium concentrations increased in conventional cultivation, fertilization, and irrigation treatments compared to pitting treatment. Generally, the concentration of different nutrient elements in plants is largely influenced by the four factors of plant genus, soil, climate, and puberty (Suttle, 2010). The concentration of phosphorus was not different in both pitting and non-pitting treatments. In fact, it can be concluded that the vetiver plant will not have any phosphorus deficiency under various moisture conditions and will show self-adaptation in all conditions or it can be deduced that one of the problems in Iran's soils is alkaline pH, i.e., the pH of more than 7. The lack of rainfall in Iran and the dry climate cause the accumulation of exchangeable nutrients in the soil (Lashkari et al., 2021; Malekzadeh Shamsabad et al., 2021) resulting in an increase in the concentration of the hydroxide ion. High alkalinity was observed in the soil of the cultivation area. Considering the results of the analysis of variance, the simultaneous use of organic fertilizer and pitting has a significant effect on the concentration of absorbed elements and improves the establishment and growth of vetiver which is in good agreement with the findings of the current study and those of Tavali (2021); Moradi (2009); Gomma and Mohamed (2007), and Arun et al. (2002) with regard to the effects of fertilization.

According to the results and diagrams, the simultaneous use of pitting and manure improves all physiological characteristics of the vetiver plant and improves the absorption and performance of the root and shoot of the plant and its other phenolic elements compared to conventional cultivation without using fertilization for the cultivated soil. These results are consistent with the results of Emami Bistgani et al. (2015), and Habibzadeh et al. (2007). In the organic fertilizer and pitting treatments, in general, the concentrations of the elements and phenol and also shoot and root lengths were more due to the improvement of the physical properties of the soil around the root as a result of using fertilizer and also because of more water absorption due to using pitting corrective action.

Conclusions

Drought stress increased the nutrient concentrations of the plant. On the whole, the results of this experiment showed that cultivation in the hole or pitting conditions increased the nutrient concentrations of the plant. Despite the fact that drought stress increased the absorption and concentration of calcium in the plant, it reduced the yield in other nutrients and elements and physiological indices. The highest susceptibility to drought stress was observed in potassium concentration and shoot height, especially when no fertilizer was given to the seedlings. Root length, phosphorus concentration, and phenol content were more affected under pitting, drought, and manure application treatments.

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Table 1. Physical and chemical characteristics of the experimental farm soil

Water holding capacity at FC (g kg-1)	ESP (%)	CEC (cmol kg^{-1})	Soil Bulk Density	Organic carbon (%)	EC(mdS/cm)	pH	Soil Texture
183.2	2.17	12.11	1.6	0.84	3.6	8	sandy-loam

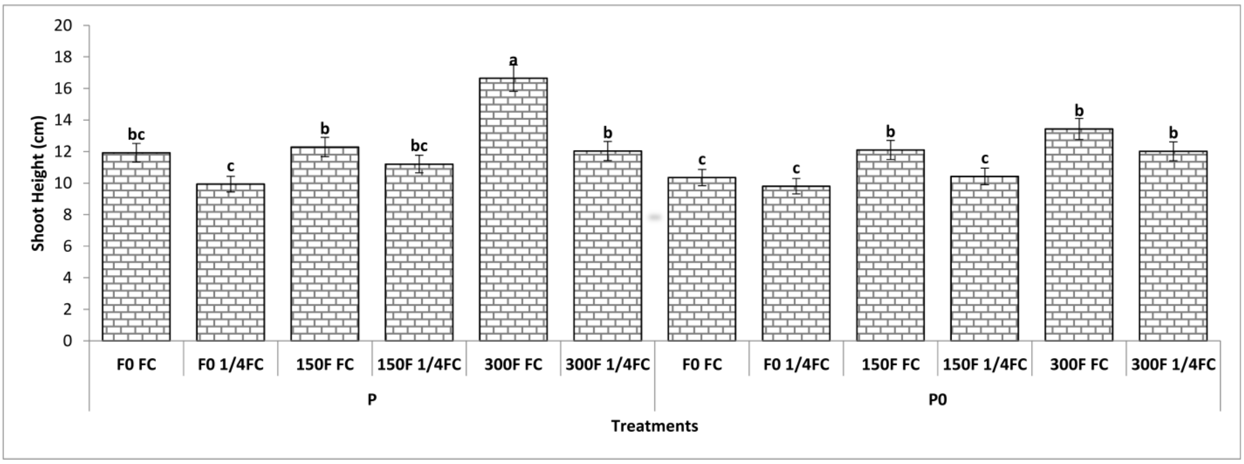

Figure 1. Interactive effect of pitting, manure application, and drought treatments on shoot height changes

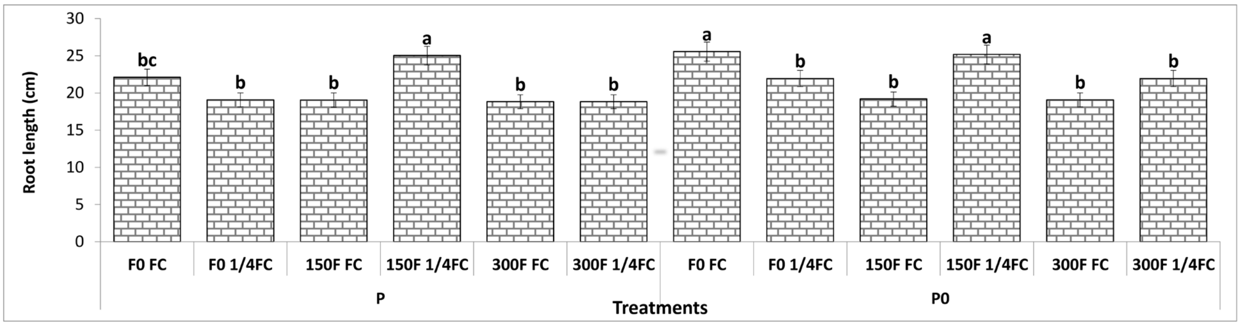

Figure 2. Interactive effect of pitting, manure application, and drought treatments on root length changes

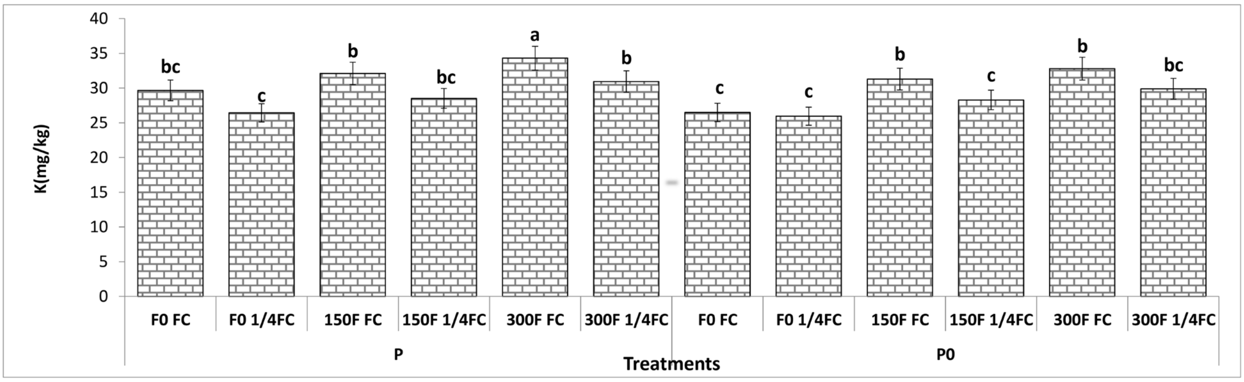

Figure 3. Interactive effect of pitting, manure application, and drought treatments on potassium concentration changes

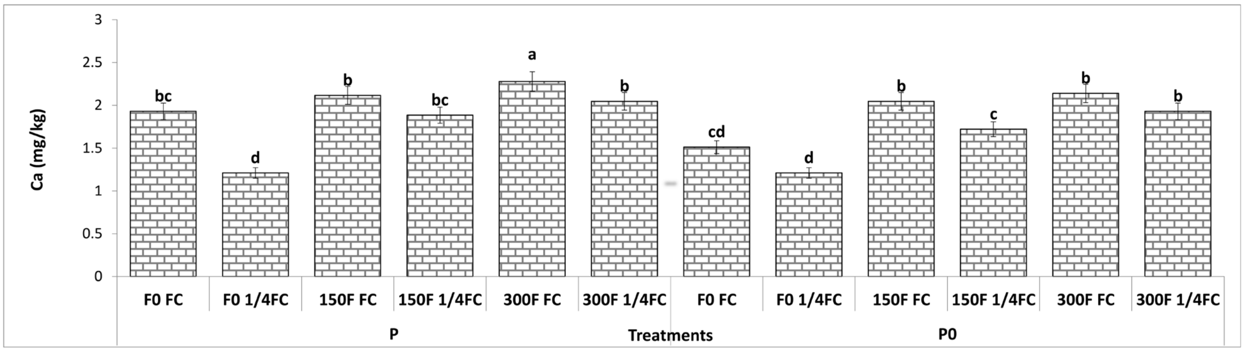

Figure 4. Interactive effect of pitting, manure application, and drought treatments on calcium concentration changes

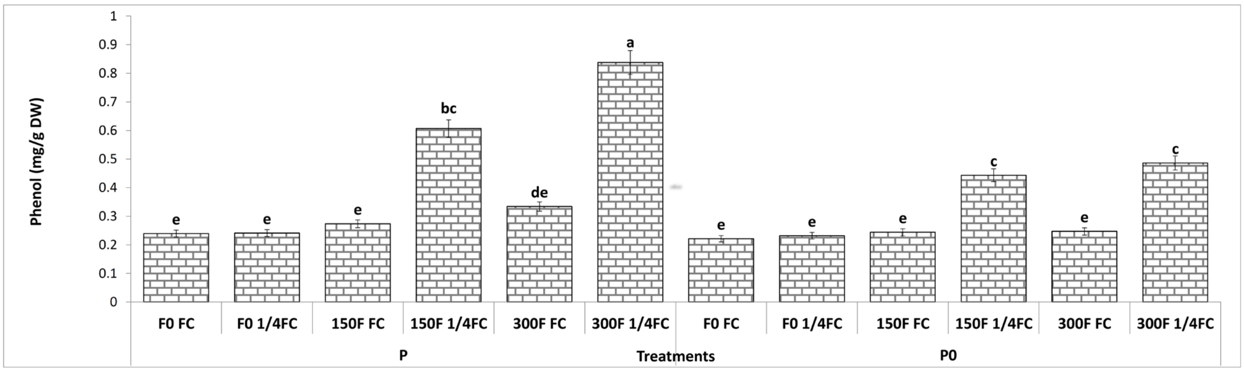

Figure 5. Interactive effect of pitting, manure application, and drought treatments on phenol concentration changes

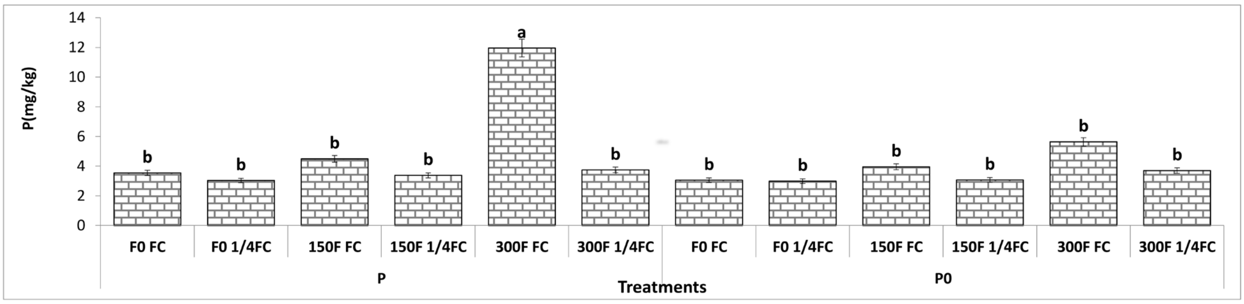

Figure 6. Interactive effect of pitting, manure application, and drought treatments on phosphorus concentration changes