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Studying the effects of mycorrhiza and vermicompost fertilizers on the growth and physiological traits of *Vetiver Grass* (*Chrysopogon zizanioides* L.)

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Abstract

As an herbaceous, perennial, and evergreen plant, *Vetiver Grass* (*Chrysopogon zizanioides* L.) can be used for the improvement and development of arid and semi-arid rangelands. To assess the interaction effect of organic and biological fertilizers on the growth and physiological traits of Vetiver grass, the dry weight of shoots and roots, essential oils, chlorophyll, carotenoids, and proline content were measured. A completely randomized design in factorial layout with three replications was performed in Malayer University's greenhouse in 2016. The treatments were mycorrhizal fungi on two inoculated (M1) and non-inoculated (M2) levels and vermicompost organic fertilizer in six levelsof (0) (control), 10, 20, 40, 60, and 80% (V1, V2, V3, V4, V5 and V6), which were added to each pot. The results showed that the interaction between different levels of vermicompost and mycorrhiza had a significant ($P<0.05$) effect on quantitative and qualitative traits of the plants. According to the results, the highest leaf dry weight was seen in VC6M1 treatment and the highest root dry weight wasobserved in VC5M2 and VC6M2 treatments. The highest percentage of essential oil content was observed in VC2M1 and VC5M2 treatments. It was also observed that in the control level of vermicompost and mycorrhizae treatment (VC1M2), the presence of proline index rose to its highest level. The maximum amount of chlorophyll a and carotenoid was seen in VC3M2treatment while the maximum percentage of chlorophyll b was observed in VC2M2 treatment.

Keywords: Biofertilizer, Rangeland, Improvement, Development, Synergistic effect

1. Introduction

All living organisms including plants need nutrients to survive. The amount of required nutrients such as the essential elements varies from plant to plant. Most soils of Iran contain less than the relative amount of essential elements required by the plant. Thus, the soil cannot produce sufficient amounts of these materials. Therefore, it is necessary to provide suitable nutrients to plants annually based on their metabolic needs in the form of fertilizers (Salim and Zahmatkesh, 2009). *Chrysopogon zizanioides*, more commonly known as *Vetiver*, is a tropical plant native to India with high adaptability to different environmental conditions (Vakhshouri, 2013; Troung *et al*., 2008). Vetiver is superior to other species of its familywith respect to adaptability and has a higher growth rate (Troung *et al*., 2008). Vetiver grass has specific features such as wide growth, resistance to insect and nematode, resistance to fire in the green state, absorption of heavy metals, resistance to temperature fluctuations, drought, acidic conditions of pH 4 and alkaline conditions of pH 8 (Rahman *et al*, 1996) and to saline soil (Jalalipoor, 2014).

The presence of organic matter in soil is of great importance to maintain soil fertility (Verma *et al*., 2013). Studies have shown that vermicomposting has a corrective effect on germination through the supply of nutrients and plant hormone production (Tomati *et al*., 1988). Therefore, the addition of vermicompost to the

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plant growth environment improves the physical and chemical properties of the soil and improves overall plant growth. As a result of high nutrient levels, the absorption of macronutrients and micronutrients by the plant increases (Nada *et al.*, 2011). Generally said that organic matter is a vital component of soil in order to maintain fertility and crop productivity (Verma *et al*., 2013). Darzi (2008) in a study of fennel (*Foeniculum vulgare* L.) have reported that the survival capacity of plants significantly increased in the presence of vermicompost fertilizer.

Symbiosis between plant roots and associated species of fungi is known as mushroom root or mycorrhiza. This coexistence enhances the ability of roots to absorb and transfer nutrients such as phosphor, copper, zinc, iron, and calcium (Lambert *et al*. 1980). In this symbiotic relationship, the mycorrhiza fungi increase nutrient and water uptake of plant roots by improving the hydraulic conductivity and osmotic adjustments of carbohydrates (Ruiz-Lozano, 2003). An increase in water uptake increases plant growth and dilutes the concentration of toxic ions generated in the plant (Juniper and Abbott, 1993). In return the plant provides carbohydrates to the fungus. Arbuscular mycorrhizal inoculations have a significant effect on the dry weight of roots and shoots based on physiological characteristics, growth parameters, photosynthetic pigments, total sugar, and total protein (Khalighi Jamalabedi, 2011). Swift (2004) reported that the use of mycorrhizal fungi has a positive impact on the growth and biomass of alfalfa plant. These fungi increase biomass by absorption of water, minerals, and growth hormones.

Since the amount of nutrition found in soil in most rangelands of Iran is not enough to grow of some rangeland plants, chemical fertilizers are commonly used for their improvement and development. The uses of chemical fertilizers cause environmental hazards to the rangelands. It seems that Chrysopogon zizanioides L. is a suitable plant species for introduction into Iranian rangelands. So this research aimed at studying the effects of mycorrhiza and vermicompost fertilizers on the growth and physiological traits of Vetiver Grass.

2. Materials and Methods

A completely randomized design in factorial layout with three replications was performed in Malayer University's greenhouse in 2016. The treatments were mycorrhizal fungi on two inoculated (M1) and non-inoculated (M2) levels and vermicompost organic fertilizer in six levels of (0) (control), 10, 20, 40, 60, and 80% (V1, V2, V3, V4, V5 and V6), which were added to each pot. The Vetiver pots were kept in the greenhouse for four months to reach appropriate conditions. At the end of experiment, the leaves and roots divided and weighted separately. The test was carried out on the interaction of mycorrhiza and vermicompost fertilizer. The chlorophyll and carotenoid contents were measured using Lichtenthaler and Wellburm's method (1983). The essential oils were obtained by Clevenger's method. The prolinecontent was measured by using the method of Bates *et al*. (1973).

3. Results

The interactions of different mycorrhizal fungi and vermicompost fertilizer on dry weight of shoots and roots, essential oils, chlorophyll, carotenoids and proline content were significant ($p < 0.05$) (Table 1).

Table 1. The results of analysis of variance (ANOVA) of the mycorrhizal fungi, vermicompost and the interactions of the mycorrhiza with vermicompost on studied traits of vetiver

Sources of variations	dry weight of leaves	dry weight of roots	Chlorophyll a (mg/g)	Carotenoid (mg/g)	Chlorophyll b (mg/g)	Proline content (µMol/gFW)	Essential oil (%)
Mycorrhizal fungi	Is	Is	Is	Is	Is	Is	Is
vermicompost	Is	Is	Is	Is	Is	Is	Is
Mycorrhiza× vermicompost	0/00*	0/00*	0/00*	0/00*	0/00*	0/00*	0/00*
significant at 0.05*					ns: not significant at 0.05		

Is: Insignificant

3.1. The effect of different fertilizer treatments on the dry weight of leaves and roots

According to the results, the combined use of mycorrhiza and vermicompost had a significant impact on the dry weight of leaves and roots (Fig. 1) and these two variables had an increasing trend. VC6M1 treatment showed the highest dry weight for leaves, while the highest dry weight for roots was observed in VC5M2 and VC6M2 treatments.

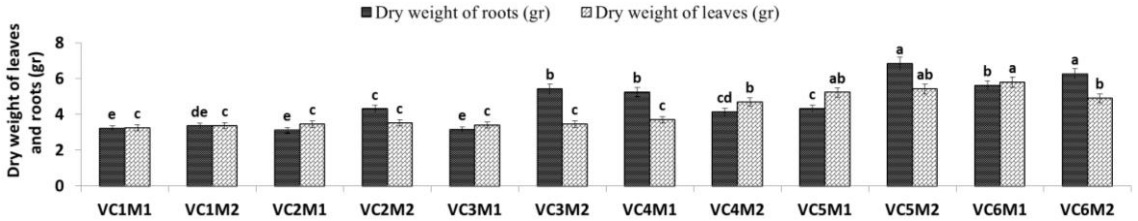

Fig.1. Net dry weight of leaves and roots under different levels of vermicompost fertilizer and mycorrhizal fungi in the plant *Chrysopogon zizanioides*. Dissimilar letters represent the significant difference that exists between different treatments. VC1, VC2, VC3, VC4, VC5, and VC6 denote levels of vermicompost treatments (0, 10, 20, 40, 60 and 80%). The letter M displays inoculations with mycorrhizal fungi treatments in the two modes of (M1) as control and (M2) (inoculated with mycorrhiza)

3.2. The effect of different fertilizer treatments on photosynthetic pigments

Based on our results, treatment with vermicompost and mycorrhiza had a significant effect on chlorophyll index (Table 2). The highest amount of chlorophyll a and carotenoidwas observed in VC3M2treatment and the highest amount of chlorophyll b was seen in VC2M2 treatment.

Table 2. The effect of different concentrations of vermicompost and mycorrhizae on chlorophyll a, b and carotenoids in the *Chrysopogon zizanioides*

Treatment	Chlorophyll a (mg/g)	Carotenoid (mg/g)	Chlorophyll b (mg/g)
VC1M1	4.77 d	3.90 e	0.73 c
VC1M2	7.00 c	9.89 b	0.18 c
VC2M1	12.21 b	9.27 b	0.42 c
VC2M2	13.92 b	14.25 a	0.06 c
VC3M1	7.66 c	2.39 e	1.82 b
VC3M2	17.94 a	7.06 c	3.64 a
VC4M1	12.65 b	10.56 b	1.15 b
VC4M2	12.44 b	7.32 c	1.14 b
VC5M1	5.36 d	5.97 de	0.12 c
VC5M2	6.85 cd	2.70 e	0.74 c
VC6M1	7.41 c	2.79 e	1.77 b
VC6M2	7.52 c	3.22e	1.22b

Dissimilar Latin letters represent the significant difference that exists between different treatments. VC1, VC2, VC3, VC4, VC5, and VC6 denote levels of vermicompost treatments (0, 10, 20, 40, 60 and 80%). The letter M displays inoculations with mycorrhizal fungi treatments in the two modes of (M1) as control and (M2) (inoculated with mycorrhiza).

3.3. The effect of different fertilizer treatments on proline

According to the results, the combined use of mycorrhiza and vermicompost fertilizer had significant effect on proline content (Fig. 2). It was observed that in (VC1M2) treatment, the presence of proline index rose to its highest level while the lowest level was observed in (VC2M1), (VC3M1), (VC3M2) treatments.

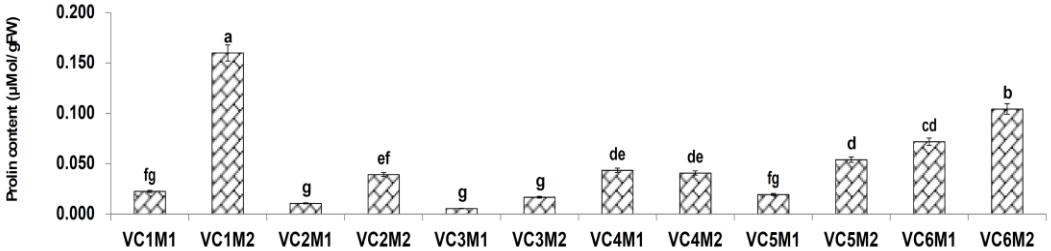

Fig. 2. The changes of proline amount under different levels of vermicompost fertilizer and mycorrhizal fungi in *Chrysopogon zizanioides*. Dissimilar letters represent the significant difference that exists between different treatments.VC1, VC2, VC3, VC4, VC5, and VC6 denote levels of vermicompost treatments (0, 10, 20, 40, 60 and 80%). The letter M displays inoculations with mycorrhizal fungi treatments in the two modes of (M1) as control and (M2) (inoculated with mycorrhiza)

3.4. The effect of different fertilizer treatments on essential oil

The results showed that the essential oil content had a significant change ($P<0.05$) under the interaction between different levels of vermicompost and mycorrhiza (Fig. 3). The highest percentage of essential oil content was observed in VC2M1 and VC5M2 treatments.

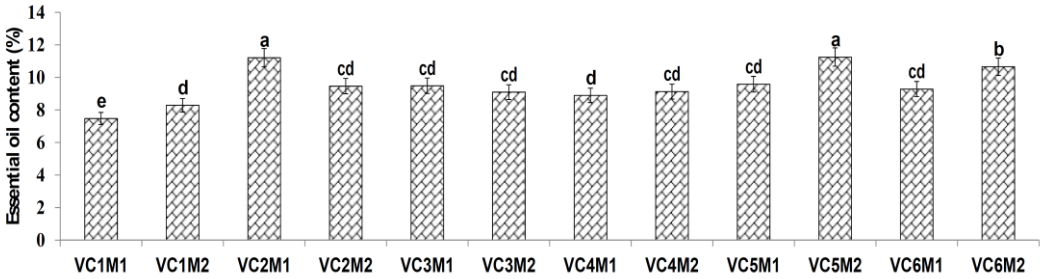

Fig. 3. The changes of essential oil percentage under different levels of vermicompost fertilizer and mycorrhizal fungi in*Chrysopogonzizanioides*. Dissimilar Latin letters represent the significant difference that exists between different treatments. VC1, VC2, VC3, VC4, VC5, and VC6 denote levels of vermicompost treatments (0, 10, 20, 40, 60 and 80%). The letter M displays inoculations with mycorrhizal fungi treatments in the two modes of (M1) as control and (M2) (inoculated with mycorrhiza)

4. Discussion

4.1. The effect of different fertilizer treatments on dry weight of leaves and roots

In general, fertilizers containing organic materials such as vermicompost satisfy the nutritional needs of plants and increase the amount of biomass (SaeedNejad, Rezvani Moghadam, 2009). With an increase in nutritional materials, the surface area of leaves increases which in turn increases their growth speed and dry weight (Soumare *et al*., 2003). While investigating the effects of vermicompost on *Dracocephalum moldavica* (also known as the Moldavian dragonhead), it is observed that vermicompost increased the absorption of water and nutritional elements (Mafakheri, *et al*., 2014). Thus, vermicompost had a positive effect on the net dry weight of leaves and the current study also supports this idea. It seems that the use of vermicompost, through a positive impact on the symbiosis of mycorrhizae with the plant, also improves the growth and development in Fennel. The results obtained by Sains *et al.* (1998) on the red clover also support the claims of our study. The symbiosis between the plant and Mycorrhizae results in an increase in water absorption through an overall increase of soil occupation by hyphae leading to an increase in the growth and dry weight of the plant (Chandra *et al*., 2010). Furthermore, fungi can increase the root growth of plants by producing plant hormones (Alguacil *et al*., 2002). Sirrenberg *et al*. (2007) showed that the root growth of plants inseminated by Mycorrhizae changes by the produced auxin.

4.2. The effect of different fertilizer treatments on photosynthetic pigments

In general, the use of an organic fertilizer such as vermicompost increases the amount of nutritional materialssuch as nitrogen available to the plant and as a result increases the overall chlorophyll and carotenoid content (Asghari *et al*., 2016). An increase in carbohydrates results in a significant increase in the quantitative and qualitative properties of leaves such as chlorophyll a and b. Similar results have also been obtained by Sadaghi Moghadam and Mirzaei, (2008). Tang *et al*. (2009) showed that in maize, fertilizer and mycorrhizae treatment increased the synthesis of chlorophyll a which in turn increased photosynthesis.

4.3. The effect of different fertilizer treatments on proline

In this study, proline was measured to evaluate the toxic effects of using fertilizers. Proline accumulation is a response to environmental stresses in plants (Vendruscolo *et al*., 2007). Accumulation of proline is obviously the result of using fertilizers (Serraj and Sinclair, 2002). On the other hand, mycorrhizal fungi have the ability to absorb nitrogen which increases proline (Amirabadi *et al*., 2013).

4.4. The effect of different fertilizer treatments on essential oil

Essential oil combinations are terpenoids and their components need nitrogen and phosphor. Vermicompost also absorbs nitrogen and phosphor finally leading to the rise of the essential oil content. Anwar *et al*. (2005) showed that vermicompost, by improving soil physical conditions and life processes, improves the access ofplants to minerals and increases the essential oil. Moreover, Gupta *et al*. (2002) observed that the amount of essential oil in mint plant inoculated with fungi considerably increased. In fact, the increase of water absorption and the macronutrients has been effective in increasing essential oil.

5. Conclusion

According to the results of this research and other previous researches, it seems that the combined use of bio-fertilizers and organic fertilizerscan be a viable alternative to chemical fertilizers. The results of present study showed that mycorrhiza and vermicompost fertilizers are suitable replacements of chemical fertilizers in rangelands. Soil nutrition and water are limited in arid and semi-arid rangelands. Therefore, the rangeland plant species grow on basis of the availability of water and soil nutrients. So, the growth and spread pattern of rangeland plant in arid and semi-arid rangelands follows of patch and inter-pathch pattern. In the case of use of mycorrhiza and vermicompost fertilizers for rangeland improvement and development, the use of these fertilizers is much less than agricultural land and is only done in pathch areas. So, According to the results of this research the use of biofertilizers is an applied method for rangeland improvement and development in arid and semi-arid areas.

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