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# The Effect of Three Types of Compost on Grass Water Use Efficiency

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**ABSTRACT**

Understanding the physical properties of compost in relation to water retention and their impact on reducing water consumption and increasing plant water use efficiency is important. In order to investigate the effect of using three types of compost (powder, vermicompost and granular) in four levels of 0, 5, 10 and 25 tons/ha on the water use efficiency of grass, a factorial project in randomized complete block design was carried out for one year and nine months (2018-2019) in at the station of the Research and Education Center of Agriculture and Natural Resources of Khorasan Razavi. The plant species tested were commercial Hamilton sports grass and was used as a culture medium in the treatments. Before planting, soil samples and compost samples were chemically and physically decomposed and macro and micronutrients were identified for each fertilizer and soil in the area. During the growth period, moisture samples were taken from the soil and irrigations were performed based on the allowable moisture discharge (50% of usable moisture). At the end of the project, the soil was sampled from each plot and the amounts of micro and macro elements were determined. The results of water use in cultivated grass treatments showed that consumption of 10 tons per hectare of vermicompost had the lowest water consumption during the growing period (430 mm), which increased water retention in the soil and the amount of water consumption was about 40% less than Control treatment (without fertilizer application). Water use efficiency was measured in different treatments that the highest water use efficiency was related to the treatment of 5 tons per hectare of powdered compost at the rate of 7.4 kg/m$^3$ of water.

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## 1. Introduction

Due to the scarcity of water resources in Iran, paying attention to increasing production per unit of irrigation water consumption (water use efficiency) is one of the important goals in agriculture. Irrigation water use efficiency depends on several factors. The most important factors affecting the severity of the effect of drought stress on crop yield depend on plant characteristics, intensity and duration of stress period, a stage of plant growth that coincides with stress and also soil fertility (Parsons *et al*., 2007).

Water use efficiency has been expressed in two ways: 1. plant water use efficiency 2. farm water use efficiency. Plant water use efficiency is the ratio of yield to plant water consumption (evaporation-transpiration) while the efficiency of farm water consumption is the ratio of yield per unit volume of water given to the farm (irrigation + rainfall), (Panda and Bahra, 2003). With proper management of water consumption and the use of water and fertilizer storage techniques in the soil, drought can be overcome to some extent. Compost is one of the water preservatives that its optimal use in agriculture will increase the efficiency of compost fertilizer and will have a significant effect on increasing water use efficiency (Shaban *et al*., 2015).

the study of changes in the available water of different soils due to the addition of hydrogel and compost showed that the amount of available water in each tissue increases compared to the control (Montesano *et al*., 2015). In general, the application of super water hydrogel at the level of 2 to 8 g/kg in the

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soil increases the amount of usable moisture by approximately 1 to 2.6 times compared to the control. However, this increase is 1 to 2.2 times in the case of compost.

The interaction effect of hydrogel and compost treatments on tomato yield was significant (P<0.001), so that the highest yield was obtained from treatment without hydrogel consumption and 30% compost at 3520 g of tomato fruit per plant (Abrisham *et al*., 2018). Also in this study, the interaction effect of hydrogel and compost consumption treatments on tomato water use efficiency was significant at the level of 1% and the highest water use efficiency was obtained from 30% compost treatment at 58 g/l.

A study was conducted to investigate the interaction of vermicompost and salinity stress on photosynthesis, transpiration and water use efficiency of red bean (Derakhshan cultivar) in seedling and flowering stages in the research greenhouse of the Ferdowsi University of Mashhad. The results showed that the effect of salinity and vermicompost stress on the mentioned factors was significant so that in the flowering stage of all vermicompost ratios, they significantly increased water use efficiency at different salinity levels compared to the control (Beyk Khurmizi *et al*., 2010). If all household waste is collected in the cities of the country and converted into compost fertilizer, 2.5 million tons of compost fertilizer will be produced annually (Mosaddeghi *et al*., 2000). He believes that the sources of organic fertilizer in Iran are limited and include livestock manure, crop residues and compost fertilizer that currently meet a maximum of 35% of the country's irrigated land needs for organic matter. Preparing vermicompost can be a good source to increase organic matter in the soil and maintain soil fertility.

It is related (Parsons *et al*., 2007) that in the study of the effect of sulfur and compost in increasing the absorption of nutrients by wheat reported that the combined use of sulfur with compost organic fertilizer increases the absorption of these elements by 78, 73, 68, 64 and 54%, respectively. Abd El-Fattah (2006) studied the effect of manure and hydrogel on the botanical properties of tomato in sandy soil and stated that the combined application of compost and hydrogel increases leaf thickness, mesophilic tissue thickness, increases the size of the phloem, the wood vessels become the thickness of the epidermal layer and the cortex.

El-Hady et al. (2006) while studying the effect of compost and hydrogel on the growth and yield of tomatoes in drip irrigation system showed that the effect of combined use of compost and hydrogel on the growth and yield of tomatoes was significant. Asgharipour et al. (2009) in the study of compost produced from municipal waste concluded that the highest percentage of germination of the dry weight of tomato plants is obtained in the ratio of soil and compost mixing 1 to 5.

The study of Bagheri et al. (2019) investigated the effect of nanocomposite superabsorbent and drought stress on the growth characteristics of sports turf was investigated, results showed the significant effect of the substrate containing superabsorbent nanocomposite on wet and dry weight and root penetration depth. Significance of the interaction between the type of substrate and the irrigation interval in the amount of proline and chlorophyll-a showed an increase in the ability of grass to pass stress in the substrate containing nanocomposite with a five-day irrigation period. It relathet (Głąb, 2014) that the effect of manure and mushroom compost on grass showed better quality than other treatments.

It is related (Barton *et al*., 2006) that stated that the effect of 6 different fertilizer treatments (control, NPK, vermicompost, poultry manure, humax and nitroxin) and three levels of irrigation treatment on the morphological characteristics of ordinary grass was significant so that vermicompost and Humax treatments at each irrigation level once every 5 days and once every 11 days for 5 days had better results than irrigation treatments. Increasing water use efficiency is of particular importance. Two factors, yield (aerial part) of grass and its water consumption are included in the formula for determining water use efficiency (yield/Vw = WUE). If the yield increases, the "water use efficiency" will increase. If lawn mowing costs a lot of money, water consumption should be reduced to increase water use efficiency. This project was implemented in order to influence the type and amount of compost on grass water use efficiency.

## 2. Materials and methods

This project was conducted using three types of compost (powder, vermicompost and granular) in four

levels of 0, 5, 10 and 25 tons/ha and three replications in a factorial complete block design under the cultivation of grass for one year and nine months (2018-2019). It was carried out at the Research and Education Center of Agricultural and Natural Resources of Khorasan Razavi. The grass plant with the scientific name *poa trivialis* of the commercial type Sport II, which was made in the Netherlands, was cultivated.

The characteristics of the compost fertilizers used in this project showed in Table 1, and the results of the tested soil are shown in Table 2.

**Table 1. Physical and chemical characteristics of Vermicompost, fresh powder compost and Granular compost of Mashhad compost factory.**

| Type of compost | EC (ds/m) | pH | Fe % | P % | K % | Na % | Water absorption % | N % | C % | O.C % | Moisture % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Vermi compost | 2 | 7 | 3.8 | 2 | 1.75 | 0.75 | 110 | 14 | 18.5 | 37 | 7.5 |
| Powder compost | <6 | 7.3 | 2.5 | 1 | 1.3 | 0.75 | 110 | 1.4 | 17 | 40 | 22.5 |
| Granular compost | <5 | 7 | 205 | 1 | 1.2 | 0.75 | 90 | 1.45 | 17.5 | 40 | 15 |

**Table 2. Physical and chemical characteristics of soil in the test area before planting grass (depth - 30 cm).**

| pH | EC dS/m | S.P % | T.N.V % | O. C% | Sand % | Silt % | Clay % | N % | P (ppm) | K (ppm) | Fe (ppm) | Mn (ppm) | Zn (ppm) | Cu (ppm) | Pb (ppm) | Cd (ppm) | F.C % | P.W.P % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.1 | 2 | 37.4 | 14.8 | 0.48 | 17 | 58 | 25 | 0.042 | 7.2 | 212 | 1.16 | 8.44 | 0.62 | 0.8 | 1.06 | 0.2 | 18.92 | 10.31 |

The results of the soil of the region show that this soil has a medium texture of silty loam and very low salinity and is not limited in terms of alkalinity. Its storage capacity (in 2013) is about 8.6% by weight.

For each type of compost (powder: P and vermicelli: V and granular: G), three values (5, 10 and 25 tons/ha) and also control SH (without fertilizer) were applied in three replications.

The number of plots for experimental treatments were as follows: No.Treatment30 = 3 control + (3 repetitions) × 3 (amount) × 3 types (vermi - powder - granular) (Fig. 1).

**Figure 1. View of the lawn planting field and application of experimental treatments.**

Before planting, the ground was prepared. Then the pipes needed for irrigation were subjected to rain pressure in the field. After that, the ground was rolled and with the help of rulers and ropes, the dimensions of the plot were landed exactly on the ground. The distance of each replication was 1.5 m and the distance of each treatment in repetition from each other was considered 0.8 m.

The sprinklers used in the adjustment type with 9 meters or 6 meters were used in the field. These sprinklers were adjusted based on 180 sprayings. An accurate meter was installed at the beginning of the field to determine the exact amount of water used for the treatments. Before planting, soil samples were taken from the ground for the complete decomposition of materials (physical and chemical). The grass was planted in early October. Fertilizers for the treatments were applied to the soil at the same time as planting. Lawn emergence began about 20 days after planting. Irrigation of the treatments took place when 50% of the soil holding capacity (FC-PWP) had been drained. This moisture was determined during the growth period by

sampling the farm soil in the treatments and placing the samples in that laboratory. The height of water used for irrigation was calculated and used from (Eq. 1).

$$\text{MAD} \quad In = \frac{(FC - PWP)}{100}.Bd.D \qquad (1)$$

Where is the height of irrigation water in centimeters and Fc is the percentage of weight moisture at the field capacity point, PWP is the percentage by weight of soil moisture at the point of wilting, Bd is the specific gravity of soil and D is the depth of root development in centimeters and MAD is the permissible moisture content. To determine the water use efficiency in the treatments, (Eq. 2) was used.

$$WUE = \frac{Yield}{V_w} \qquad (2)$$

In which the yield of grass yield in kg/ha, $V_w$ volume of water consumption in $m^3$/ha and WUE in kg/$m^3$.

The type of seed used is Hamilton II Sport, which is one of the seeds used by the municipality. To plant grass, the following operations were performed: 1- Land loader and disk 2- Rollers 3- Rope and removing the boundaries of plots 4- Sprinkling seeds on rolled land 5- Spraying fertilizers (with soft sand) on the ground and seeds 6 - Irrigation with a hose immediately after planting. A sprinkler irrigation system was used after grass seed germination. Intensive care, as well as irrigation and other operations, took time and all the notes were kept on it. It should be noted that urea, phosphate and potassium fertilizers were not used in this project and only treated compost fertilizers were used. Evapotranspiration and water consumption factors, soil water use efficiency were studied.

## 3. Results and discussion

Evaporation, rainfall and evaporation and transpiration of grass: Table 5 shows the evaporation, rainfall and evapotranspiration of the plant during the grass growth period (2018-2019).

The results show that rainfall during 2018-2019 could not compensate for the rate of evaporation from the pan. On the other hand, in this year, the rate of evaporation from the pan was always less than the rate of evaporation and transpiration of the plant. Evaporation, rainfall and evaporation and transpiration of grass in grass growth period (2018-2019) showed in Table 3.

**Table 3. Evaporation, rainfall and evaporation and transpiration of grass in growth period (2018-2019).**

| Month | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Sum. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precipitation (mm) | 37.8 | 41.3 | 17.6 | 0 | 0 | 0.1 | 0 | 13.1 | 6.8 | 21 | 68 | 28.9 | 234.6 |
| Evapotranspiration | 88.2 | 137 | 204.2 | 242.5 | 244.9 | 195.6 | 127 | 67.8 | 44.3 | 39 | 33 | 31 | 1454.5 |
| Evaporation of pan (mm) | 140 | 244 | 342 | 386 | 374.3 | 343 | 204 | 198 | 193.3 | 156.8 | 148.6 | 180.9 | 2910.9 |

The results of Table 3 and Fig. 2 indicate that the evaporation and transpiration of the grass plant during 2018-2019 are equivalent to about 50% of the evaporation from the evaporation pan. On the other hand, the amount of rainfall during this year is about 8% of evaporation from the evaporation pan and about 16% of grass evaporation and transpiration.

As can be seen from Fig. 3, V10 treatment is the treatment of consumption of 10 tons/ha of vermicompost that had the lowest amount of irrigation water. This treatment had the highest water retention and because the irrigation cycle was based on 50% of the storage capacity discharge, in this treatment the discharge was 50% later and caused the irrigation cycle to be longer than other treatments and less water consumption compared to other treatments. The amount of water consumed in this treatment was 40% less than the control treatment.

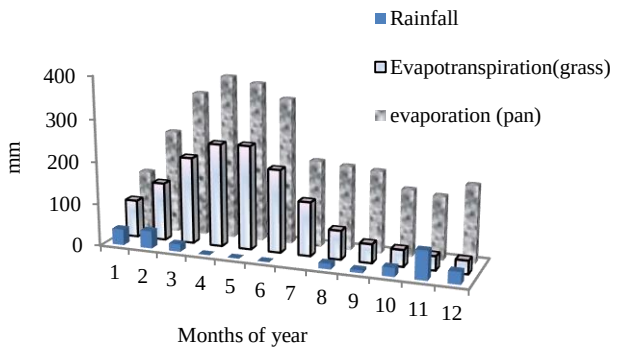


**Figure 2. Changes in evaporation rate, Evaporation and transpiration of grass and rainfall in different months of the year (2018-2019).**

According to Fig. 3 it was found that vermicompost fertilizer treatments had the highest water retention and the least water consumption during the growth period, and then powder compost fertilizer is the second in this field. Granular fertilizer also retains water but is less than other fertilizers and about 20% of water consumption in this treatment is less than the control (without fertilizer).

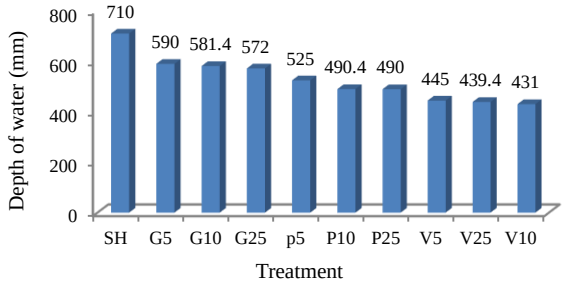


**Figure 3. Water consumption (irrigation + rainfall) of different treatments during the growth period of 2018-2019 (mm).**

*3.1. Water use efficiency during the growing season*

During the growth period of four cuttings, the grass was harvested from different treatments. The first lawn mowing was done in early June. The growth period of this harvest was two months and it was related to April and May. The second harvest was taken from the project treatments at the beginning of August. The growth period of this crop was two months and it was related to July and August. The yield was calculated (kg/m$^2$). The third crop was taken from the project treatments at the beginning of October. The growth period of this harvest was two months and it was related to August and September. The fourth harvest was taken from the project treatments at the beginning of January. The growth period of this harvest was three months and it was related to October, November and December. Then, according to the water consumption (rainfall + irrigation), the water consumption efficiency was calculated from the relevant formula. Having the yield and water consumption during the growth period, the water consumption efficiency formula during the growth period was obtained. In Table 6, these values are calculated and given.

Table 4 shows that the highest water use efficiency is related to the use of 5 tons/ha of powdered compost in lawn planting, in which the water use efficiency is equivalent to 7.4 kg of grass shoots per cubic meter of water. The lowest water consumption efficiency of the control treatment is equivalent to 2.7 kg of grass shoots per cubic meter of water.

**Table 4. Water yield and consumption (rainfall + irrigation) and water use efficiency in the entire growth period of 2018-2019.**

| Treatment | Water using (mm) | Yield (kg) | WUE (kg/m$^3$) |
|---|---|---|---|
| $p_5$ | 525 | 11.75 | 7.4 |
| $G_{10}$ | 581.4 | 8.3 | 4.7 |
| $P_{25}$ | 490 | 8.3 | 5.7 |
| $G_{25}$ | 572 | 7.8 | 4.5 |
| $G_5$ | 590 | 7.4 | 4.2 |
| $P_{10}$ | 490.4 | 7.2 | 4.9 |
| $V_{25}$ | 439 | 6.1 | 4.7 |
| SH | 710 | 5.8 | 2.7 |
| $V_5$ | 445 | 5.6 | 4.2 |
| $V_{10}$ | 431 | 4.0 | 3.1 |

From the results of Fig. 4 it is inferred that the treatments of powder compost fertilizer (especially the use of 5 tons/ha) have the highest water use efficiency compared to other treatments. Since vermicompost treatments had the lowest water consumption (Fig. 2) it can be concluded that the high yield of grass in powder compost treatments had a superior advantage over low water consumption in vermicompost, which made them more the results of the soil of the region show that this soil has a medium texture of silty loam and very low salinity and is not limited in terms of alkalinity. Its storage capacity is about 8.6% by weight.

For each type of compost (powder: P and vermicelli: V and granular: G), three values (5, 10 and 25 tons/ha) and also control SH (without fertilizer) were applied in three replications.

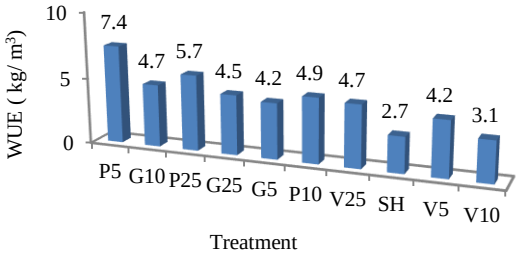


**Figure 4. Water use efficiency (WUE) during the growth period of 2018-2019.**

Organic matter due to the improvement of soil structure increases water retention in the soil and the soil loses its moisture later (Abd El-Fattah, 2006). It had the highest soil moisture retention. This experiment showed that the application of vermicompost fertilizer

had the highest water retention in the soil and the next degree, powdered compost fertilizer had the highest soil moisture retention. This causes a delay in soil moisture loss and can increase the irrigation cycle in these treatments and save water consumption. This finding is in accordance with the results of Mohammadnejad et al. (2015). Water use efficiency with the use of compost fertilizer in powder form (up to 5 tons/ha) was significantly increased compared to other treatments. Significant increase in yield (deduction of water use efficiency formula) was the highest and therefore it is recommended to use this material in lawn planting and then the use of vermicompost was also effective in increasing its consumption efficiency.

The grass is one of the most important pillars in green space that the greenness and freshness of the grass are very important in terms of scenery in the beauty of cities. More durability and freshness of the grass depend on the presence of sufficient moisture in the bed, so it is necessary to use powdered compost fertilizer at a rate of 5 tons per hectare to achieve maximum durability and freshness of the grass. Due to the limitation of water in cities and the importance of saving water consumption, the use of vermicompost at a rate of 10 tons/ha can also save a lot of water while plant is applied with nutrients that are essential for proper growth. This is in accordance with Ahmadinejad et al. (2013) findings on wheat crop.

Using the excessive volume of compost fertilizer, both powder and vermicelli will not have much effect on water use efficiency, so in this study, the use of 25 tons/ha of powder or vermicompost fertilizer did not increase water use efficiency.

Since the price of water has been increasing in recent years and due to the reasonable price of powdered compost fertilizer compared to vermicompost fertilizer, the use of compost fertilizer to increase water use efficiency is a priority.

## Conflict of interests

All authors declare no conflict of interest.

## Ethics approval and consent to participate

No human or animals were used in the present research.

## Consent for publications

All authors read and approved the final manuscript for publication.

## Availability of data and material

All the data are embedded in the manuscript.

## Authors' contributions

All authors had an equal role in study design, work, statistical analysis and manuscript writing.

## Informed consent

The authors declare not to use any patients in this research.

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