# ROLE OF VERMICOMPOST AND PERLITE FOR SUSTAINABLE WHEAT (*TRITICUM AESTIVUM* L.) GROWTH UNDER DROUGHT STRESS

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**Abstract**

Drought is the most drastic abiotic factor that restricts plant growth and harms wheat production. Under changing climatic scenarios, water scarcity is a severe danger to wheat production, particularly in dry and semi-arid countries. The effect of vermicompost and perlite on wheat (*Triticum aestivum* L.) growth under water stress was investigated in a pot experiment. At the vegetative stage, growth characteristics were evaluated. In comparison to the control, vermicompost and perlite increased shoot length 41% and 30.31%, shoot fresh weight 20.43% and 18.99%, shoot dry weight 56.84% and 59.4%, root length 33% and 16%, root fresh weight 89.37% and 8.61%, root dry weight 40.18% and 7.24%, leaves fresh weight 51.92% and 12.17%, leaves dry weight 59.48% and 21.47%, and leaf area 43.81% and 36.89%. In contrast to the drought, vermicompost and perlite increased shoot length 41% and 38.8%, shoot fresh weight 46.16% and 65%, shoot dry weight 88.34% and 84.1 root fresh weight 62.96% and 35.23%, root dry weight 40.05% and 9.99% leaves fresh weight 95.28% and 42.32%, leaves dry weight 59.48% and 21.47% and leaf area 43.81% and 36.89% but decrease in root length 40.05% and 9.99%. Under water stress, vermicompost and perlite can help wheat grow better.

**Keywords:** Drought, perlite, stress, vermicompost, wheat

## Introduction

One of the main challenges faced in the 21st century is adequate food production for an immensely increasing population under the severe pressure of climatic changes (Pawlak and Kołodziejczak, 2020) Climatic changes drastically modify the weather patterns and ensued erratic rainfall incidents and severe temperature fluctuations. These climatic instabilities ultimately evoke severe drought episodes, threatening agricultural production (Abberton *et al*., 2016). Most of the areas in Pakistan are dominated by arid-semiarid climatic conditions with shallow rainfall intervals. Pakistan is listed among the most drought-prone countries globally, and water shortage is the most challenging situation faced by Pakistan today (Enum, 2013; Sidiropoulos *et al*., 2021). Thus, a massive population growth, decline in water supplies, and climatic variations aggravate the agricultural yield. Additionally, inappropriate soil management with excessive agricultural activities further degrades agronomic soil (Yu *et al*., 2013; Yadav *et al*., 2021). Hence, the essential requisites of the present era are to economize water utilization by the agricultural sector and stabilize soils to enhance their water absorption characteristics (Wilhite 2005; Hussain *et al*., 2008; Gerard *et al*., 2017). Soil amendments such as vermicompost and perlite have the great prospective for improving soil moisture retention capacity and plant available moisture (Sohail-Ur-Raza *et al*., 2015) by enhancing soil aggregation processes (Omondi *et al*., 2016), ventilation, nutrient, and moisture-holding capacity (Deksissa *et al*., 2008; Novak *et al*., 2009; Major *et al*., 2010; Mohan *et al*., 2018). Consequently, it decreases surface runoff and leaching of nutrients and moisture (Jien and Wang, 2013; Alvarez *et al*., 2019) with better production responses of the crops even under water-scarce conditions (Sharif *et al*., 2004; Sohail-Ur-Raza *et al*., 2015). Vermicompost has been shown to promote beneficial microbial populations and so improve soil fertility (Kiran, 2019). In Pakistan vermicompost have been recently shown to increase soil quality and productivity by improving soil chemical characteristics, increasing plant-available nutrients, improving soil biological activities, having a positive impact on absolute growth attributes, and increasing wheat crop yields under water stress (Hafez *et al*., 2021). Furthermore, it is high in humic acid and hormones, which have a beneficial influence on absolute growth attributes such as root length, root fresh and dry weight, shoot length, shoot fresh and dry weight, leaf fresh and dry weight and leaf area (Ahmad *et al*., 2021). Organic amendments usually affect soil structure by forming secondary pores, which act as capillaries for the roots. Vermicompost amendment in the soil enhances the proportion of mesopores and macropores that improve soil particles' aggregate stability (Liu *et al*., 2007; Xue *et al*., 2019). It can enhance the availability of moisture and nutrients to plants (Nguyen *et al*., 2012; Ebrahimi *et al*., 2021). Perlite is a silica-rich hydrous compound produced by a volcanic eruption (Von Aulock *et al*., 2013; Garde *et al*., 2022). It is a greyish compound with water retention capacity, i.e., 20 times greater than its volume (Pichor and Janiec, 2009; Bruneel *et al*., 2020). On the other hand, Perlite has been recently shown to increase soil water holding capacity, improving absolute growth attributes such as root length, root fresh and dry weight, shoot length, shoot fresh and dry weight, leaf fresh and dry weight, and leaf area, as well as increasing wheat crop yields under water stress (Ahmadi *et al*., 2021). In the future, due to severe climatic changes, more prolonged dry periods are predicted, so it is the right time to devise some strategies to cope with such situations. For this purpose, it is essential to understand better the performance of vermicompost and perlite in soil for wheat growth under water stress.

## Materials and Methods

A pot experiment was performed to assess the influence of vermicompost and perlite to improve wheat growth under water stress during Rabi season in 2020 at Botanical Garden, University of Gujrat, Gujrat. Seeds of wheat variety Zincol-16 was acquired from National Agriculture Research Center (NARC), Islamabad. Vermicompost and perlite was obtained from local market. Pots of 30 cm diameter were used in the experiment. Each pot was filled with 10 kg sandy loam soil and mixed 1 tons $ha^{-1}$ vermicompost and 1 tons $ha^{-1}$ perlite. The pots were assembled according to completely randomized design. There were six treatments with three replicates. Then 20 seeds were sown each pot. Water stress was applied at vegetative stage of wheat plants. Following growth parameters were studied after stress imposition. Shoot length, root length, shoot and root fresh and dry weights and leaf area. The results were statistically analyzed by Minitab one-way ANOVA and inter-treatment variation was determined by Post-hoc Fisher test.

## Results and Discussions

The result presented in **Fig.1** indicated that mean values for shoot length (cm) of plant grown in the control, drought, vermicompost, and perlite, and there was traced significant variation ($p<0.001$) in shoot length (cm) among treatments. The effect of vermicompost and perlite on shoot length (cm) was 41% and 30.31% higher as compared to control, and they had a significant difference ($p<0.001$). Under drought conditions, the shoot length (cm) of vermicompost and perlite was 41% and 38.8%, significantly higher than drought. The mean values for shoot fresh weight (g) of plants grown in control, drought, vermicompost, and perlite and there was traced significant variation ($p<0.001$) in shoot fresh weight (g) among treatments as shown in **Fig. 2**. The shoot fresh weight (g) of plants was 20.43% and 18.99% higher grown in the treatment of vermicompost and perlite as compared to control, and they had a significant difference ($p<0.001$). Under drought conditions, plants were treated with vermicompost and perlite; their shoot fresh weight (g) was 46.16% and 65%, significantly higher than the drought. As shown in **Fig. 3**, the mean values for shoot dry weight (g) of plants grown in control, drought, vermicompost, and perlite showed significant variation ($p<0.001$) in shoot dry weight (g) among treatments. Plant shoot dry weight (g) was 56.84% and 59.4% higher in the vermicompost and perlite treatments than in control, and the difference was significant ($p<0.001$). Wheat plants were grown with vermicompost and perlite during a drought, their shoot dry weight (g) was 88.34% and 84.1% higher than the drought, and they had significant differences ($p<0.001$). The result indicated that the shoot length, shoot fresh weight, and shoot dry weight were lower in drought than in control. Drought inhibits cellular growth by causing cell wall shrinkage due to reduced water potential and transpiration rates, which results in a drop in turgor pressure across the cells, lowering cell volume and, as a result, reducing cell division in plants, which could be the cause of lower shoot length and shoot fresh and dry weights (Fathi and Tari, 2016). The effect of vermicompost and perlite on shoot length, fresh, and dry weight was positive under drought stress. Shoot length, shoot fresh weight, and shoot dry weight were increased might be due to the beneficial effects of vermicompost, which stimulates soil microbial activity, enhances oxygen availability, maintains average soil temperature, improves soil porosity and water infiltration, improves nutrient content, and improvements the plant growth (Rekha *et al*., 2018). Similarly, the perlite boosted shoot length, fresh weight, and dry weight due to its high CEC capacity to store water and nutrients (Ghehsareh *et al*., 2011; Mahmoud *et al*., 2021).

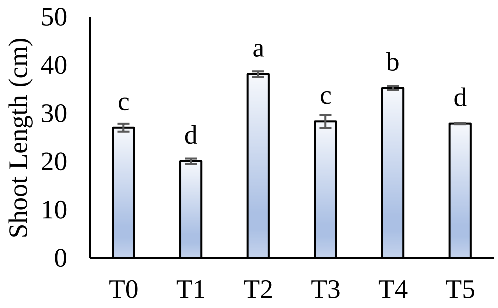


Fig. 1 Role of vermicompost and perlite for improving Shoot Growth (cm) under drought stress.

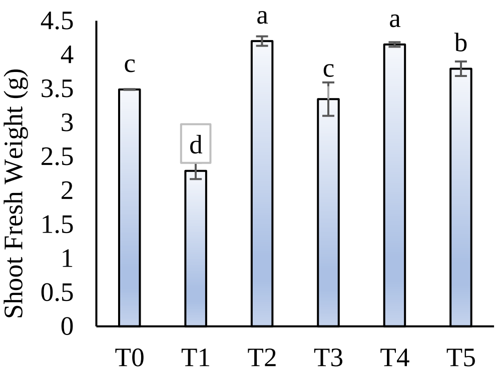


Fig. 2 Role of vermicompost and perlite for improving Shoot Fresh Weight (g) under drought stress

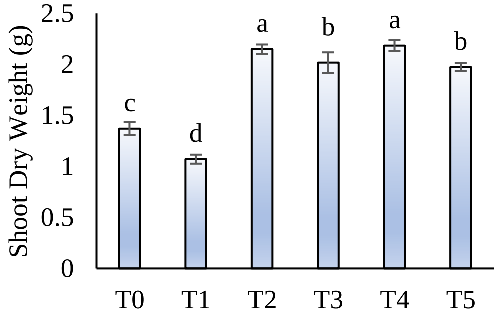


Fig. 3 Role of vermicompost and perlite for improving Shoot Dry Weight (g) under drought stress

The result presented in **Fig. 4** indicated that mean values for root length (cm) of plant grown in the control, drought, vermicompost, and perlite, and there was traced significant variation (p<0.001) in root length (cm) among treatments. The effect of vermicompost and perlite on root length (cm) was 33% and 16% higher as compared to control, and they had a significant difference (p<0.001). Under drought conditions, the root length (cm) of vermicompost and perlite was 14.23% and 16.65%, significantly lower than drought. The mean values for root fresh weight (g) of plants grown in control, drought, vermicompost, and perlite and there was traced significant variation (p<0.001) in root fresh weight (g) among treatments as shown in **Fig. 5**. The root fresh weight (g) of plants was 89.37% and 8.61% higher grown in the treatment of vermicompost and perlite as compared to control, and they had a significant difference (p<0.001). Under drought conditions, plants were treated with vermicompost and perlite. Their root fresh weight (g) was 62.96% and 35.23%, significantly higher than drought. As shown in **Fig. 6**, the mean values for root dry weight (g) of plants grown in control, drought, vermicompost, and perlite showed significant variation (p<0.001) in root dry weight (g) among treatments. Plant root dry weight (g) was higher 40.18% and 7.24% in the vermicompost and perlite treatments than in control, and the difference was significant (p<0.001). Wheat plants were grown with vermicompost and perlite during a drought, their root dry weight (g) was 40.05% and 9.99% higher than the drought, and they had a significant difference (p<0.001). The result indicated that the root fresh weight and root dry weight were lower in drought than control, but the root length was higher under drought. Deep roots, which absorb and transport water and nutrients, may provide drought tolerance by absorbing water from the deep soil layer; hence, root length was longer in drought (Kim *et al*., 2020). Low moisture soil drives the higher allocation of assimilates to the roots and modifies carbon absorption in the roots to increase the surface area for water uptake, resulting in increased root fresh and dry weight (Sonobe *et al*., 2010; Joseph *et al*., 2020). The result indicated the positive effect of vermicompost and perlite on root length, root fresh, and root dry weight. The availability of humic acid and various micro-and macronutrients, which are converted into more plant-available forms during vermicomposting, may be attributable to the increased root length, root fresh weight, and root dry weight (Vukovic *et al*., 2021). More significant moisture conservation and microclimate, better aeration for increased root oxygen demand, and higher water and nutrient absorption were all factors that might increase root length, root fresh weight, and root dry weight in perlite (Elizabeth *et al*., 2018).

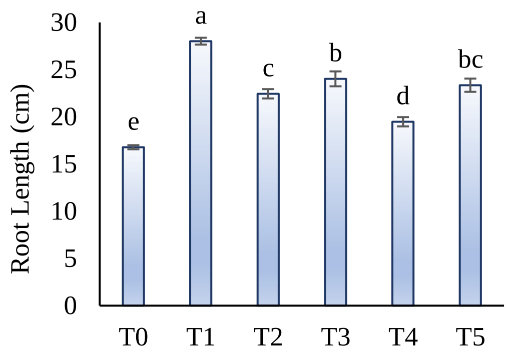


Fig. 4. Role of vermicompost and perlite for improving Root Length (cm) under drought stress.

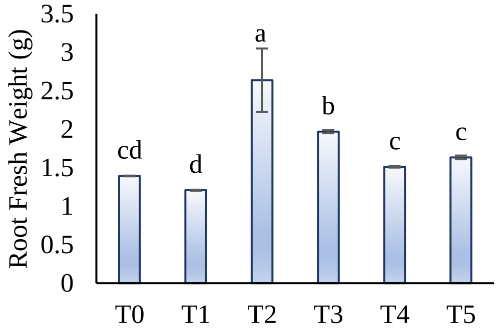


Fig. 5. Role of vermicompost and perlite for improving Root Fresh Weight (g) under drought stress

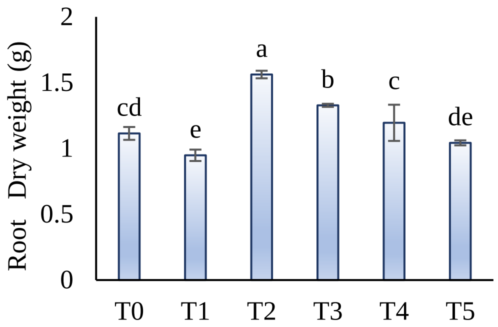


Fig. 6. Role of vermicompost and perlite for improving Root Dry Weight (g) under drought stress

The mean values for leaves fresh weight (g) of plants grown in control, drought, vermicompost, and perlite and there was traced significant variation (p<0.001) in leaves fresh weight among treatments as shown in **Fig. 7**. The leaves fresh weight (g) of plants was 51.92% and 12.17% higher grown in the treatment of vermicompost and perlite as compared to control, and they had significant difference (p<0.001). Under drought conditions plants were treated with vermicompost and perlite. Their leaf's fresh weight (g) was 95.28% and 42.32%, significantly higher than drought. As shown in **Fig. 8**, the mean values for leaves dry weight (g) of plants grown in control, drought, vermicompost, and perlite showed significant variation (p<0.001) in leaves dry weight (g) among treatments. Plant leaves dry weight (g) was 51.18% and 27.13% higher in the vermicompost and perlite treatments than in control, and the difference was significant (p<0.001). Wheat plants were grown with vermicompost and perlite during a drought, their leaf's dry weight (g) was 59.48% and 21.47% higher than the drought, and they had a significant difference (p<0.001). The result presented in **Fig. 9** indicated that mean values for leaf area (cm2) of plant grown in the control, drought, vermicompost, and perlite, and there was traced significant variation (p<0.001) in leaf area (cm2) among treatments. The effect of vermicompost and perlite on leaf area (cm2) was 38.61% and 27.33% higher as compared to control, and they had a significant difference (p<0.001). Under drought conditions, the leaf area (cm2) of vermicompost and perlite was 43.81% and 36.89%, significantly higher than drought.

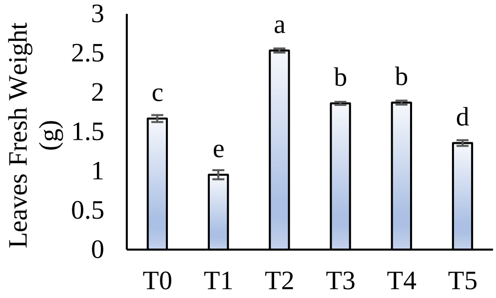


Fig. 7. Role of vermicompost and perlite for improving Leaf Fresh Weight under drought stress

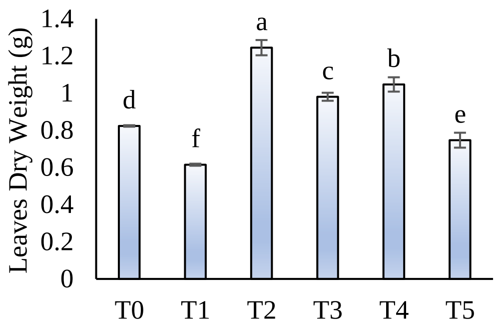


Fig. 8. Role of vermicompost and perlite for improving leaf Dry Weight under drought stress

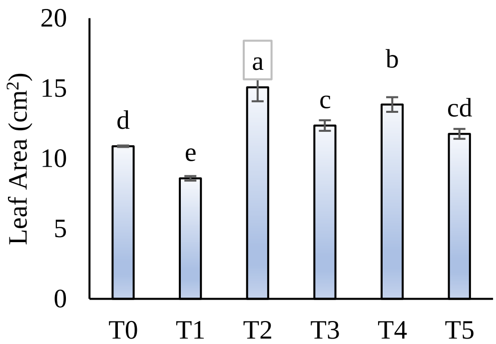


Fig. 9. Role of vermicompost and perlite for improving Leaf Area (cm$^2$) under drought stress

The result indicated that the leaf's fresh weight and leaves dry weight was lower in drought as compared to control due to the lower water potential inside the leaves and the poor photosynthetic rate, leaf expansion and production were reduced under water stress, resulting in a decrease in assimilate supply to the plant leaves (Anjum *et al*., 2011; Rehman *et al*., 2021). Drought stress during the vegetative stage can reduce crop fresh and dry weights and leaf area, limiting plant production sustainability. This could be because drought stress changes the stomatal aperture and cell turgidity of leaves, resulting in lower $CO_2$ absorption and transpiration rates and inhibiting leaf metabolism, stomatal conductance, leaf water potential, leaf area index, leaf growth, leaf fresh and dry weight, and leaf area (Saddiq *et al*., 2021). The result indicated that vermicompost and perlite improved the leaf's fresh weight, leaf dry weight, and leaf area under drought. Vermicompost, which are peat-like materials with high porosity, aeration, drainage, and water-holding capacity, can have various physical and chemical properties that affect plant growth, higher leaf fresh and dry weight, and leaf area (Moradi *et al*., 2014; Singh and Bhartiya, 2021). Perlite has a closed cellular structure, with the majority of water held superficially and released slowly at relatively low tension, providing excellent medium drainage and rhizosphere aeration. Due to these beneficial features, perlite may have a higher leaf area and fresh and dry weight (Ors and Anapali, 2010; Markoska *et al*., 2018)

Note: Figure showing in wheat plants where T0=Control, T1=Water stress, T2=Vermicompost, T3=Vermicompost+Drought,T4=Perlite,T5=Perlite +Drought and same letters bars shows non-significan difference.

## Conclusions

Water stress drastically reduced the wheat growth as ca be seen by decline in leaf area and leaf fresh and dry weights. However, vermicompost and perlite-treated soil increased growth characteristics of wheat as indicated by improved leaf area, shoot and root fresh and dry weights. The best results of absolute growth parameters were obtained in the presence of vermicompost and perlite. As a result, the current study concluded that vermicompost and perlite have a synergistic effect on growth characteristics of wheat and reduces the detrimental effects of water stress.

## Conflict of Interest

All Authors declares that they have no conflict of interest.

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