

Effect of Water Stress and Soil Amendments on Growth Parameters of Wheat (*Triticum aestivum* L.)

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ABSTRACT

A field experiment was conducted during the *rabi* seasons of 2023–24 and 2024–25 to study the effect of water stress stages and soil amendments on growth parameters of wheat (*Triticum aestivum* L.). The experiment comprised four water stress treatments *viz.*, control (no stress), water stress at tillering, flowering and grain filling stages, and five soil amendment treatments *viz.*, control, biochar @ 2 and 4 t ha⁻¹, and vermicompost @ 2 and 4 t ha⁻¹. The experiment was laid out in a split plot design with three replications. Growth parameters such as plant height, dry matter accumulation and number of tillers meter⁻¹ row length were recorded. Results revealed that no water stress (control) recorded significantly higher plant height (74.72 cm), dry matter accumulation (11.05 g plant⁻¹) and number of tillers (80.05 ml⁻¹ row length) in pooled analysis. Among stress stages, water stress at the tillering stage caused maximum reduction in growth parameters. Application of biochar @ 4 t ha⁻¹ significantly improved plant height (73.88 cm), dry matter accumulation (10.87 g plant⁻¹) and number of tillers (80.28 m⁻¹) over control. Overall, a higher dose of biochar proved superior in mitigating the adverse effects of water stress and improving growth of wheat.

Key words: Wheat, Water stress, Biochar, Vermicompost, Growth parameters

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of India and plays a vital role in food and nutritional security. However, its productivity is severely affected by water stress, particularly when stress occurs at critical growth stages such as tillering, flowering and grain filling. Water stress reduces cell expansion, photosynthetic activity and dry matter accumulation, ultimately limiting crop growth and yield.

Soil amendments like biochar and vermicompost have gained attention due to their potential to im-

prove soil physical properties, water holding capacity and nutrient availability. Biochar enhances soil moisture retention and microbial activity, while vermicompost supplies readily available nutrients and improves soil structure. Therefore, the combined evaluation of water stress stages and soil amendments is essential to develop strategies for mitigating moisture stress in wheat.

Materials and Methods

A field experiment was conducted during the *rabi* seasons of 2023–24 and 2024–25 at the Instructional

Farm, RCA, MPUAT, Udaipur to study the effect of water stress and soil amendments on growth parameters of wheat (*Triticum aestivum* L.). The experiment comprised of four water stress treatments *viz.*, control (no stress), water stress at tillering, water stress at flowering and water stress at grain filling stage, and five soil amendment treatments *viz.*, control, biochar @ 2 t ha⁻¹, biochar @ 4 t ha⁻¹, vermicompost @ 2 t ha⁻¹ and vermicompost @ 4 t ha⁻¹, thereby involving 20 treatment combinations. The experiment was laid out in a split plot design with three replications, assigning water stress treatments to main plots and soil amendments to sub-plots. The height of five randomly tagged plants from each plot was measured from the base of the plant to the tip of the fully opened leaf of the main shoot at 90 DAS. The mean plant height for each treatment was computed and expressed in centi-meters (cm). The number of tillers meter⁻¹ row length was recorded by counting all tillers from a one meter length row at randomly selected locations in each plot at 60 DAS and expressed as tillers m⁻¹ row length. The dry matter accumulation at 90 DAS was recorded by uprooting five randomly selected plants from each plot. The collected plant samples were chopped and placed in separate perforated paper bags, sun-dried for 2–3 days and thereafter dried in a hot air oven at 70 °C for 72 hours until a constant weight was obtained. The dry weight of each sample was recorded and averaged to compute dry matter accumulation plant⁻¹, which was expressed as g plant⁻¹.

Results and Discussion

Plant height

Water stress: An assessment of data (Table 1) water stress exerted a significant influence on plant height of wheat during both the years of experimentation as well as in pooled analysis (Table 1). Across years, the maximum plant height at 90 DAS was recorded under control (no stress), whereas water stress imposed at tillering stage resulted in the minimum plant height. Water stress at flowering and grain filling stages caused comparatively less reduction in plant height and remained statistically at par with the control during pooled analysis. On pooled basis, control treatment recorded plant height of 74.72 cm, which was significantly higher than water stress at tillering stage. The reduction in plant height under early stage water stress may be attributed to limited cell elongation, reduced turgor pressure and suppressed meristematic activity under moisture deficit conditions. Similar reductions in plant height of wheat due to water stress at early growth stages have been reported by Farooq *et al.* (2014) and Shao *et al.* (2008).

Soil amendments: It is explicit from data significantly improved plant height irrespective of water stress levels. Among soil amendments, biochar @ 4 t ha⁻¹ recorded the highest plant height in pooled analysis, followed by vermicompost @ 4 t ha⁻¹. Both treatments were significantly superior to control. The improvement in plant height with biochar ap-

Table 1.

Treatments	Plant height (cm)			Dry matter accumulation (g plant ⁻¹)			Number of tillers (m ⁻¹ row length)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
Water stress									
W ₁ : Control (No stress)	74.24	75.20	74.72	10.96	11.14	11.05	80.55	80.56	80.05
W ₂ : Water stress at tillering	64.44	66.18	65.31	9.53	9.84	9.68	68.49	70.30	69.40
W ₃ : Water stress at flowering	69.31	71.09	70.20	10.04	10.41	10.22	79.51	80.69	79.60
W ₄ : Water stress at grain filling	73.10	74.85	73.97	10.77	11.14	10.95	78.03	81.96	81.00
S.Em.±	2.020	1.899	1.26	0.24	0.25	0.13	2.17	2.06	1.34
C.D. (P=0.05)	6.99	6.57	3.89	0.85	0.90	0.40	7.50	7.11	4.14
Soil amendments									
B ₁ : Control	66.71	67.66	67.18	9.79	10.04	9.91	73.03	74.41	73.72
B ₂ : Biochar 2 t ha ⁻¹	70.91	72.56	71.73	10.41	10.74	10.57	77.24	79.09	78.17
B ₃ : Biochar 4 t ha ⁻¹	72.81	74.95	73.88	10.69	11.06	10.87	79.23	81.33	80.28
B ₄ : Vermicompost 2 t ha ⁻¹	69.18	70.34	69.76	10.18	10.41	10.30	75.52	76.77	76.15
B ₅ : Vermicompost 4 t ha ⁻¹	71.73	73.65	72.69	10.55	10.91	10.73	78.20	80.29	79.25
S.Em.±	1.08	1.14	0.83	0.16	0.18	0.13	1.21	1.34	0.96
C.D. (P=0.05)	3.11	3.30	2.35	0.48	0.52	0.38	3.50	3.85	2.70

plication could be attributed to enhanced soil moisture retention, improved soil structure and increased nutrient availability, which promoted better vegetative growth. These findings are in conformity with the results reported by Zhang *et al.* (2012), Blanco-Canqui (2017) and Ibrahim *et al.* (2020).

Dry matter accumulation

Water stress: Dry matter accumulation at 90 DAS was significantly affected by water stress treatments during both years and in pooled analysis. Maximum dry matter accumulation was recorded under no stress condition, while water stress at tillering stage resulted in the lowest dry matter accumulation. Water stress at flowering and grain filling stages showed intermediate values. On pooled basis, control treatment accumulated 11.05 g plant⁻¹, whereas water stress at tillering stage accumulated only 9.68 g plant⁻¹, indicating a substantial reduction in biomass production under early moisture stress. Reduced dry matter accumulation under water stress might be due to decreased photosynthetic rate, reduced leaf area development and impaired assimilate translocation. Similar findings have been reported by Passioura (2007) and Gupta and Singh (2016).

Soil amendments: Among soil amendments, biochar @ 4 t ha⁻¹ recorded the maximum dry matter accumulation, followed by vermicompost @ 4 t ha⁻¹. Both treatments significantly enhanced dry matter accumulation over control. Biochar improves soil aeration, water retention and nutrient availability, leading to increased photosynthetic efficiency and biomass accumulation. These results corroborate the findings of Lehmann and Joseph (2015), Liu *et al.* (2017) and Ibrahim *et al.* (2020).

Number of tillers

Water stress: Number of tillers meter⁻¹ row length was significantly influenced by water stress during both years and pooled analysis. Maximum tillers were recorded under no stress condition, while water stress at tillering stage resulted in the lowest tiller count. This indicates that tillering stage is highly sensitive to moisture stress. On pooled basis, control treatment produced 80.05 tillers m⁻¹, which was significantly higher than water stress at tillering stage (69.40 tillers m⁻¹). Moisture stress during tillering likely restricted tiller initiation and increased tiller mortality due to reduce assimilate availability. Similar observations have been reported by Passioura (2007) and Farooq *et al.* (2014).

Soil amendments: It is explicit from data significantly enhanced tiller production. Among treatments, biochar @ 4 t ha⁻¹ recorded the highest number of tillers, followed by vermicompost @ 4 t ha⁻¹. Improved soil moisture regime and nutrient availability under biochar application favoured tiller initiation and survival. These findings are in agreement with the reports of Zhang *et al.* (2012), Blanco-Canqui (2017) and Suthar (2009).

The present investigation clearly demonstrates that water stress, particularly at tillering stage, adversely affects growth parameters of wheat. Application of soil amendments, especially biochar, effectively mitigated the adverse effects of water stress by improving soil moisture retention, nutrient availability and root environment. Biochar, being a porous and carbon-rich material, enhances soil physical properties and reduces drought-induced stress, thereby promoting better crop growth (Lehmann and Joseph, 2015; Neethu *et al.*, 2018).

Vermicompost also improved growth parameters by supplying readily available nutrients and enhancing microbial activity; however, its effect was comparatively lower than biochar under water stress conditions. Similar comparative advantages of biochar over vermicompost under moisture-limited environments have been reported by Liu *et al.* (2017) and Blanco-Canqui (2017).

Conclusion

On the basis of results obtained from the present investigation, it can be concluded that water stress at tillering stage is most detrimental to growth of wheat. Among soil amendments, application of biochar @ 4 t ha⁻¹ proved most effective in improving plant height, dry matter accumulation and number of tillers, and remained at par with vermicompost @ 4 t ha⁻¹. Therefore, application of biochar @ 4 t ha⁻¹ can be recommended as an effective soil amendment for mitigating adverse effects of water stress in wheat.

Conflict of Interest- None

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