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Effect of different irrigation practices on wheat roots

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Abstract
Wheat is a prominent cereal crop in Indian agriculture. Roots are a major contributor to the nutrient's uptake and wholly in water uptake from soil. Aim of this experiment is to study the impact of various irrigation practices on root morphology of wheat crops. Wheat (*Triticum aestivum* L.) is sown in Randomized BLock Design at Research farms of ICAR-CSSRI during *Rabi* 2021-22. It was observed that roots of treatment irrigated with sprinkler water had better roots in terms of morphology. 20% higher total root surface area and 36% more number of secondary roots were recorded in the sprinkler irrigation system plot as compared to traditional flooding practice plot.

Keywords: Wheat, roots, micro-irrigation

Introduction

World population is multiplying by an exponential rate and India is one of the major contributors. According to Economics times of India, upto April 2023, India had overtaken China in population demographics which also increased pressure on farming communities to produce more and more even with the limited amount of resources and time. Increased air temperatures and incidence of heat stress, adverse effect on climate is obvious with greater changes in rainfall patterns, increasing chances of hazards like drought or flooding (Hammer *et al.* 2020) [8]. In this scenario, various technological advancements in the agricultural sector like climate smart farming approaches, precision agriculture, aeroponics and hydroponics are playing a major role in elevating crop production. Although these measures are highly productive, their cost of implementation repels the majority of farmers. Wheat is a staple crop for the majority of the Indian population; hence it is essential to apply technological advancements to boost its growth.

Wheat being a member of the grass family has a monocotyledon root system, a primary and numerous secondary and tertiary root. Development of the root system is governed by various stimuli, *i.e.*, soil moisture, texture, compactness, climatic factors and plant genetics. The spatial distribution of plant roots in soil reflects potential water and nitrogen uptake capacity. Moreover, yield advantages of deeper roots in the field have been demonstrated in the experiments of Lopes and Reynolds (2010) [11] and Li *et al.* (2019a, b) [9, 10] on bread wheat. Water is a limited and unfairly distributed resource in the country. Traditional flooding method of irrigation is highly inefficient because of higher water demand and losses with low water productivity which is unable to ensure food security for the Indian population. Conservation agriculture practice of irrigation from drip and sprinklers is a boon to water scarce areas. It is evident from the past researches that irrigation level and frequency have a great impact of root formation as under excessive irrigation root growth may be limited by lower oxygen diffusion rate, higher soil strength under scarce moisture and more fibrous and shallow roots under frequent irrigation. Micro-irrigation is a significant and eco-friendly alternative of flood irrigation. As we are heading towards precise agricultural practices under which judicious use of water is a major factor for sustainable farming, the impact of micro irrigation practices that can create marked morphological alterations in root's characteristics (length, intensity, root hair, number of tips and forks) should be known. Hence, micro-irrigation systems like drip and sprinkler irrigation systems were studied in an experiment conducted.

Materials and Methods

An experiment was carried out at the research farm of ICAR-Central Soil Salinity Research Institute, Karnal during the *Rabi* 2021-22 on the wheat crop (*Triticum aestivum* L.) in order to study the above-mentioned influences. The experiment was conducted in randomized block design (RBD) with five replications.

Treatments consist of conventionally tilled wheat with 6.5 cm surface irrigation provided at critical phenological stages (CRI, tillering, jointing, dough, and flowering) without straw mulch *i.e.*,

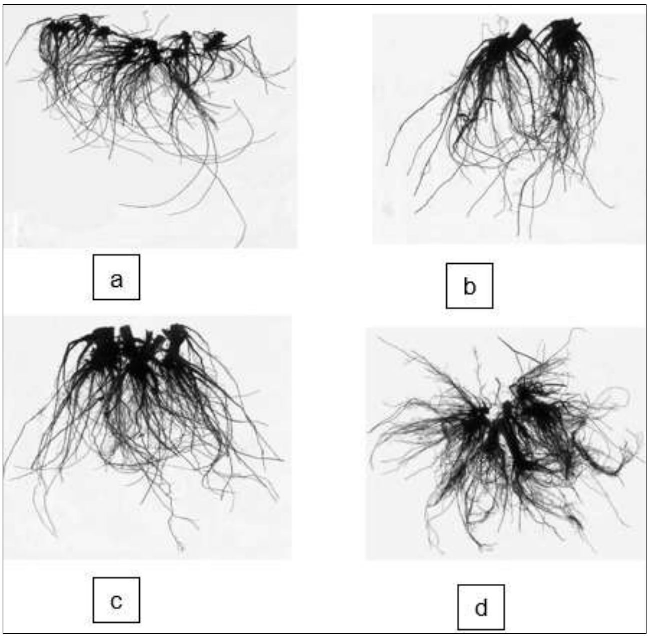
- Farmer's practice (T_1)
- Zero-tilled wheat with straw mulch and drip irrigation plot (T_2)
- Zero-tilled wheat with straw mulch and surface irrigation at critical phenological stages plot (T_3)
- Zero-tilled wheat with straw mulch and mini-sprinkler irrigation plot (T_4).

Root samples were collected with help of a shovel at 10-12 cm depth. Roots were washed thoroughly with water and various parameters (total root length, projected area, surface area, diameter, and root volume, number of tips, forks and crossings) were measured using Root scanner. WinRHIZO2019 was installed and used to obtain and study the images with appropriate data.

Results and Discussion

Root system of a plant plays an essential role in water uptake and maintenance of soil–plant–atmosphere continuum (Guo *et al.*, 2016) [6], hence, it gives a fair picture of plants overall growth and production. Cereal root system is composed of fine roots and the entire root system is covered with root hairs (Nestler *et al.* 2016a, b) [13, 14].

Treatments	Total root length (cm)	Total Surface Area (cm²)	Average Diameter (mm)	Root Volume (cm³)	Number of Tips	Number of Forks	Number of Crossings
T_1	206.68	13.91	0.61	1.31	1277.60	2458.80	353.80
T_2	168.35	12.44	0.56	0.84	948.07	1913.67	298.87
T_3	213.45	14.48	0.65	1.37	1185.47	2593.60	380.93
T_4	232.40	16.86	0.63	1.47	1660.20	3811.13	590.67
General mean	205.22	14.42	0.61	1.25	1267.83	2694.30	406.07
p-Value	0.415	0.0621	0.286	0.251	0.438	0.523	0.512
CV (%)	10.929	8.087	8.322	29.042	18.829	27.024	29.047
SE(d)	9.734	0.505	0.023	0.159	100.783	334.815	56.874



Here, a- roots of T_1, b- roots of T_2, c- roots of T_3 and d- roots of T_4

Effect on total root length (cm)

On an average, total root length of wheat crop is recorded highest in sprinkler irrigated system (232.40 cm) which is 11% higher than the roots from flooding irrigation plot (206.68 cm), followed by roots of drip irrigation plot (213.45 cm). Zhao *et al.* (2018) [17] in his study on winter wheat observed that under optimal field conditions 89.2% of the roots in all growth stages (from seedling to maturity) were distributed in the upper soil profile (0–40 cm) where moisture was highly available.

Effect on total surface area (cm²)

Higher the water availability of moisture to plants, the larger the root surface area which generates a greater surface area for resource uptake in plants (Elazab *et al.*, 2016) [5]. Sprinkler irrigated plot roots have the highest surface area (16.86 cm²) as longer root hairs favor larger rhizosheath formation mainly depending on soil water content (Haling *et al.* 2014) [7], whereas conventional plot roots have 13.91 cm² area.

Effect on average diameter (mm)

Average root diameter is observed highest in drip irrigated plot (0.65 mm) followed by sprinkler irrigated plot (0.63 mm) and flood irrigated plot (0.61 mm). Elazab *et al.*, 2016 [5] in their respective studies explained that thick root systems have higher metabolic expenses (production and maintenance of root tissues, measured in carbon units) producing more biomass than thinner roots. Whereas Corneo *et al.*, 2016 [4] and Aziz *et al.*, 2017 [2] observed contrasting results.

Effect on root volume (cm³)

Difference in root volume among all the plots is not significant. More root volume enhances plant's performance by drought tolerance due to the mucilage water-holding capacity overcoming the decline in rhizosphere hydraulic conductivity during soil drying (Zickenrott *et al.* 2016) [16]. with thick root systems (Elazab *et al.*, 2016) [5]. While Corneo *et al.*, 2016 [4] and Aziz *et al.*, 2017 [2] agree on the counter side of this approach their findings.

Effect on number of tips, forks and crossings

Flood irrigated plot roots have 24% lesser root tips, 36% lesser root forks and 59% lesser number of crossings as compared to sprinkler irrigated plot roots. Comparatively lesser amount of water in drip and sprinkler irrigated plot, hydrotropism in their roots is observed where lateral root primordia localize to available water (Bao *et al.* 2014) [3], hence, mew grow roots after a rewetting event are formed vigorously (Sebastian *et al.* 2016) [15]. When roots penetrate in hard soils, these find the cracks, pores and fissures soil peds and show growth even in adverse environments (Atkinson *et al.* 2019) [1].

Conclusion

It is evident from the above study that frequent application of irrigation by sprinklers at smaller intervals helped to produce longer, denser and thicker roots with higher surface area as compared to heavier and less frequent amounts provided via flooding. It is also observed that because of precise irrigation via drips, roots were shallow and more fibrous, whereas in flooded wheat, deeper roots were found. Compact soil of T_4 due to less moisture availability at lower layers was also a major reason behind roots being less deep and more fibrous.

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