environmental sciences proceedings

MDPI

Proceeding Paper

Evaluation of the Water Distribution Efficiency of Wheat under Improved Water and Fertilizer Application Techniques †

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† Presented at the 1st International Precision Agriculture Pakistan Conference 2022 (PAPC 2022)—Change the Culture of Agriculture, Rawalpindi, Pakistan, 22–24 September 2022.

Abstract: The application of water-retention polymers with improved fertilizers is a better crop-growing technique, especially in soils where the water-retention capacity is low. In Pakistan, different types of fertilizers, such as urea, DAP, MOP or SOP, are used from sowing to harvesting of crops. The use of water-retention polymers in low water-retaining soils is very important to increase its retention time. The experiment was conducted on half an acre of land in FFC Research Center located in Dyyalgarh, Millat Rd., near Deputy Wala interchange M4, Faisalabad, Punjab, Pakistan. The seed variety used in this experiment is zincole and the seed rate is 50 kg/acre. This experiment contains four different treatments, and each treatment contains three replicates. In T1, no water-retention polymers were used, while T2 was treated with standard and neem-coated urea under no water-retention polymer application. While in T3 and T4 recommended doses of polymers were used with standard and neem-coated urea. Irrigation scheduling was determined using tensiometers.. The research is aimed to keep moisture available in the root zone for better growth. For proper moisture monitoring tensiometers were installed.

Keywords: tensiometer; zincole; polymers; dry matter; neem; water retention

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Citation: Anjum, L.; Rasheed, Q.; Rizwan, M.; Rehman, A.; Zamir, M.S.I. Evaluation of the Water Distribution Efficiency of Wheat under Improved Water and Fertilizer Application Techniques. *Environ. Sci. Proc.* **2022**, *23*, 25. https://doi.org/10.3390/environsciproc2022023025

Academic Editor: Muhammad Naveed Anjum

Published: 26 December 2022

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1. Introduction

Agriculture imparts a vital role in the economy of Pakistan. Pakistan has the largest irrigation system in the world that contributes towards agricultural production [1]. The agriculture fulfills 40% of the world's food requirements by consuming 60% of its fresh water reserves. However, as population increases the demand for food also increases and the gap between demand and supply also widens. This gap needs to be filled by adopting new techniques for sowing crops to provide a "high-yield per drop of water" [2].

Wheat is the major crop of every agricultural country. It is very important for socio-economic growth. Wheat is required for food for both humans and animals. Wheat has a positive impact on a country's GDP. If there is shortage of wheat in a country, t will negatively affect the economic conditions as well as the population's food needs will not be met. Therefore, proper management strategies need to be adopted for the healthy growth and good yield of wheat to ensure a country's growth. Water shortage is a critical global issue, with developed countries also facing this problem. Such countries have reduced conventional farming methods and adopted new techniques to conserve soil moisture and soil water in the root zone [3]. They have applied water directly into the root zone where plants can more efficiently use this water. Certain modern techniques are known today which have been adopted by developed countries and are receiving the benefits from these techniques. The problem with modern techniques is that they require technical labor for effective use. The lack of technical labor also causes loss due to the improper use of

instruments. Natural water-retention measures have also been adopted to increase water-retaining capacity of aquifers, soil, and aquatic and water-dependent ecosystems [3,4]. The agriculture sector utilizes the largest amount of water, almost 90%, and remaining water is utilized for household and industrial purposes [5]. Water availability is crucial in Pakistan because the per capita water availability is reduced to 1000 m^3 per annum, internationally considered as the water shortage threshold value [6]. In this highly stressed water profile, the major reasons which lead to the fall in the agriculture sector are population increases, rapid urbanization, and the reduction in agricultural land.

Under these circumstances, a field experiment was conducted on wheat crops using water-retention polymers in the Fouji Fertilizers Research Center of Faisalabad. The purpose of study was to develop the optimal irrigation schedules for wheat based on the different deficit levels and the following parameters were investigated, water productivity, crop yield and the development of an optimal irrigation schedule for wheat.

2. Methodology

The experimental site (geographical coordinates 31.430 N (latitude) and 73.07 degree E (longitude)) was selected at the FFC Dyyal Garh Faisalabad, Punjab, Pakistan. Wheat crop was studied from 2019–2020 to analyze the irrigation schedule and sowing techniques under RCBD statistical design (layout as shown in Table 1). Insecticide was applied to the crop as a precautionary measure to prevent the attack of insects. Fungicide was also applied to protect the crop from fungi. The use of fertilizer is very important for the better growth of any crop. For this purpose, the liquid fertilizer NPK was applied to fulfil the deficiency of macro-nutrients in the soil. There were four treatments under flood irrigation and a control under a furrow irrigation system.

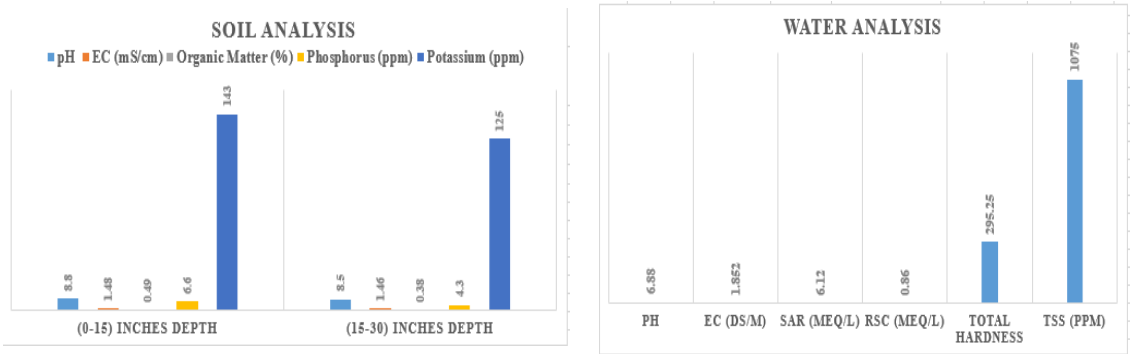
Table 1. RCBD layout plan of the study area.

R3T2	R3T4	R3T1	R3T3
R2T4	R2T3	R2T2	R2T1
R1T1	R1T2	R1T3	R1T4

T1 = Recommended dose of N (standard urea), P (DAP) and K (MOP) fertilizers with four irrigations (with no application of water-retention polymers);
T2 = Recommended dose of N (neem-coated urea), P (DAP) and K (MOP) fertilizers with four irrigations (with no application of water-retention polymers);
T3 = Recommended dose of N (standard urea), P (DAP) and K (MOP) fertilizers with four irrigations (with 100% application of water-retention polymers);
T4 = Recommended dose of N (neem-coated urea), P (DAP) and K (MOP) fertilizers with four irrigations (with 100% application of water-retention polymers).

Soil and Water Sampling

The soil samples were taken from the field irrigated with groundwater flood irrigation. The water samples were collected from running tube-wells by adopting the standard procedure of sampling (Figure 1).



(**a**) (**b**)

Figure 1. (**a**) Soil analysis, and (**b**) water analysis.

3. Results

Crop Harvesting Parameters

The harvesting and growth parameters are crucial to assess the crop growth over time. These are indications of the crop conditions and helps in finding the results of the experimental site. The different parameters of wheat were tested as shown in Figures 2–4.

The results shows that plant height and spike length is higher when neem-coated urea was applied. The results show that while comparing standard urea and neem-coated urea, standard urea had a good effect on crop yield. Comparing price, standard urea is cheaper than that of neem-coated urea so is a better option for crop growth in Pakistan.

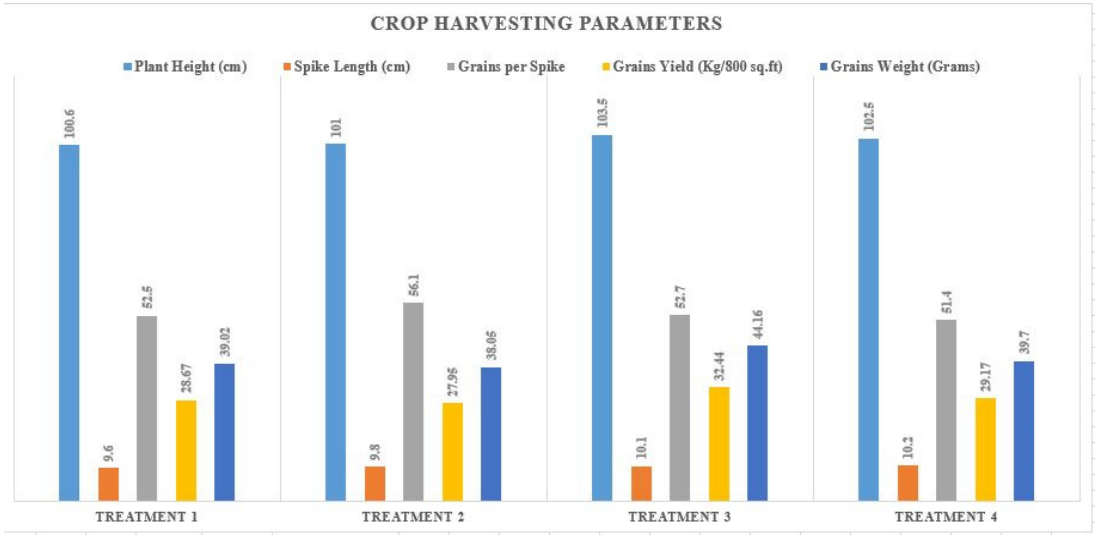


Figure 2. Graphical representation of the harvesting parameters.

Histogram and Normal Probability Plot of Crop Harvesting Parameters

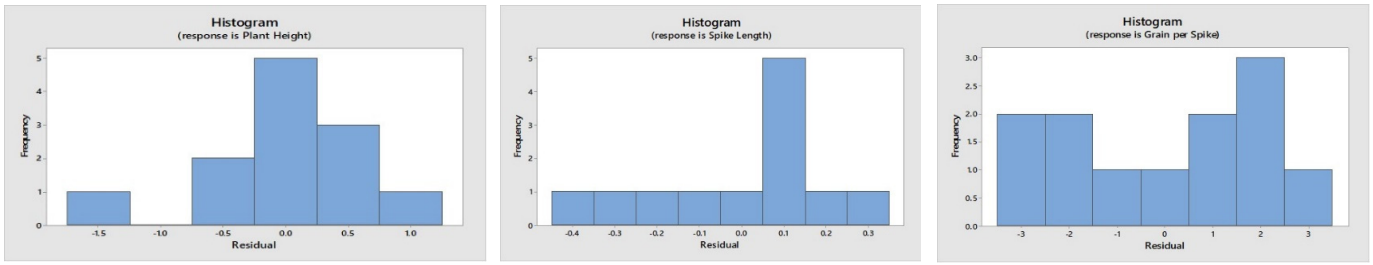


Figure 3. *Cont.*

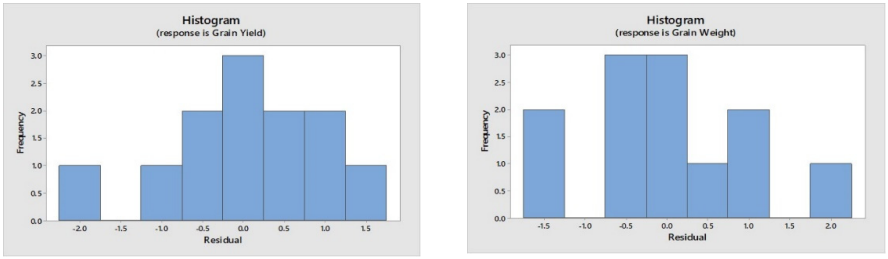


Figure 3. Histogram of the harvesting parameters.

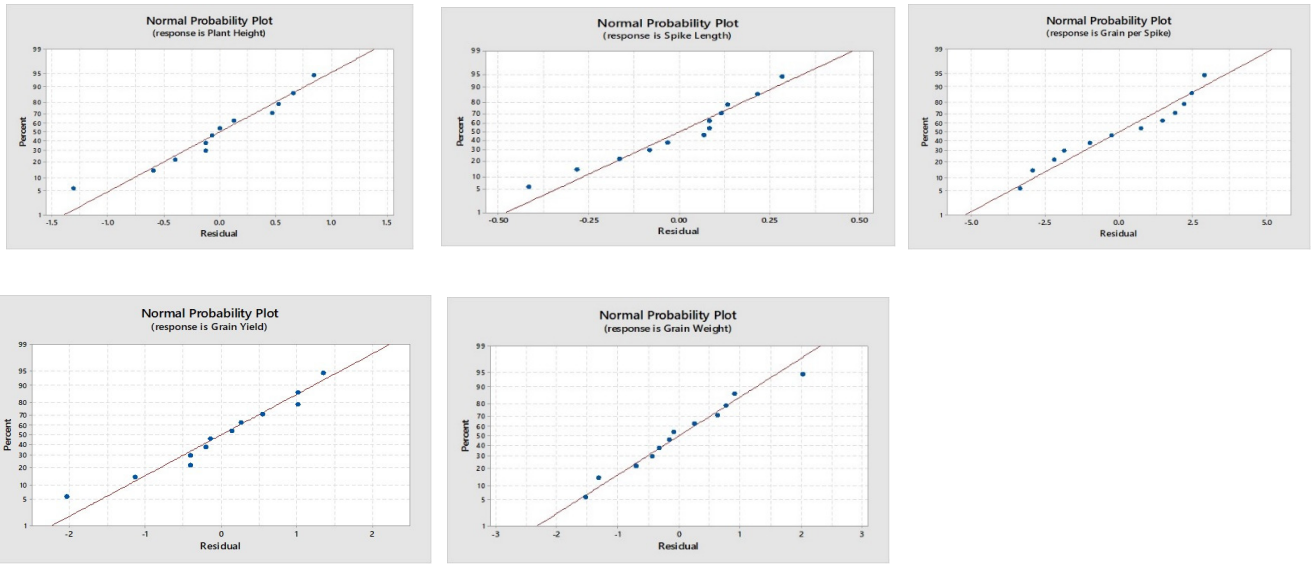


Figure 4. Normal probability plot of the harvesting parameters.

4. Conclusions

The results from the tensiometers show that water remained available to the crops when the recommended doses of the water-retention polymers were applied. The yield analysis showed that the yield was maximum with T3 treatment, where 100% of the recommended doses of the water-retention polymers with standard urea were applied. Crop conditions (plant height, grain weight, etc.) were good with T3 treatment of the recommended doses of the water-retention polymers.

Author Contributions: L.A. and Q.R. gathered and processed the data and performed the experiments. L.A. and M.R. supervised the experiments. L.A., A.R., M.R., Q.R. and M.S.I.Z. to analyzing the results and writing the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data is available upon request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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