In-vitro Evaluation of Urea and Zinc Sulphate with Comparison of Polluted Water on the Growth of Chilli under Drip Irrigation System

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Abstract

Application of micronutrients is increasing day by day because they promote growth quickly and ultimately increases the yield of field crop, while polluted water used for irrigating crop has negative effect on growth and development of crop. Drip irrigation saves water and nutrients and also minimizes the disease risk. An experiment was conducted to investigate the different supplements (Zinc Sulphate, Urea and Polluted Urea) through drip irrigation on the growth of chilli. Two varieties of chilli (I and II) were used in this study with four replications. During current study number of leaves and height of seedling were measured regularly and data were analyzed. Zinc Sulphate ($ZnSO_4$), Urea ($CO(NH_2)_2$) and polluted water were compared with control group. Chilies irrigated with zinc sulphate show less growth than control because large quantity of zinc sulphate was applied. Polluted water has negative effect on growth of crop that's why chilli showed minimum growth. While maximum growth were recorded after the application of urea that was 8.82% more than control in variety I and in variety II growth were 5.78% more than control group.

Keywords: *Polluted Water, Urea and Zinc, Growth of Chilli, Drip Irrigation System.*

Introduction

Chilies are most widely used as a spice and particular taste to cooked food. Chilies mostly found in red and green color, red powdered chilies are available in the market and green chilies are used in salad and for many other cooking purposes. Chilies used as condiments too and it has excellent nutritive value.

Capsaicin is a spicy capsaicinoid chemical compound which is produced by the Capsicum fruits as a secondary metabolites. Although the most research data refers to chili as a raw fruit, but this alkaloid compound has been utilized in different

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traditional medicines for many years for its analgesic and anti-inflammatory qualities. The pure capsaicin's antiradical effectiveness also used against two human tumor cell lines (Lavorgna et al., 2019). Chili *(Capsicum annuum L.)* is a commercially important spicy crop grown in many parts of the world due to its various beneficial uses (Ghafoor et al., 2022).

Chili *(Capsicum annuum L.)* is a popular food in addition with many therapeutic properties. The results show that there is a considerable variation in growth and yield related features in chili as a result of the use of plant growth regulators (Anolisa et al., 2020).

Micro and micro nutrients in the form of fertilizers like urea and zinc sulphate are important in plant physiology, growth, and development because they stimulate metabolic processes and improve quality. Micronutrients cause significant changes in plant metabolic processes, influencing production. In recent years, the function of micronutrients in crop productivity and quality has grown in importance, particularly in chilli (Naik, 2018). Drip irrigation offer the complete flexibility regarded to fertigation and potential of efficient water delivery. Drip irrigation saves 30% water and fertilizer (Zhang et al., 2022). The uncontrolled dumping of urban garbage, mining, and the heavy use of herbicides, insecticides, fungicides, and other agrochemicals were important sources of pollution and reason for worry. The impact of these heavy metals on plants and their metabolic processes induced by heavy metal redistribution due to pollution of water. Polluted water negatively affect the plant growth attributes (Asati et al., 2016).

Objectives of the Study

1. To know the growth of chilies under drip irrigation.
2. To investigate the effect of urea and zinc sulphate on the crop of chilli.
3. To determine the effect of polluted water on the vegetative growth of chilli crop.

Material and Methods

Experiment was executed in the wire house of Botany Department of Ghazi University, Dera Ghazi Khan during winter season. Selected species for the experiment was chilli; seeds were obtained from local market of Dera Ghazi Khan. Water was applied after sowing of seeds. Specific area was selected for growing the nursery.

Nutritional supplement used during the experiment were zinc sulphate, urea and polluted water with dosage 3 ml in 1000 ml, 3g in 1000 ml and 100ml respectively. Thirty six pots were used in the experiment, nine for each treatment. Pots were filled with equal quantity of loamy soil and animal manure.

Plants were taken from the nursery and transplanted in the pots that were filled with 330grams of compost. Transplanting was done after two month of sowing. Two plants were transplanted in single pot. For each treatment, plants of variety I were transplanted in first four replicates and plants of II variety in next five replicates in a single row. Plants were transplanted at the height of 1 to 2 centimeter.

Plants were irrigated with the drip irrigation system that was arranged in row planting method. Row to row space was about 5 cm and plant spacing in a row was 3 cm. Plants were irrigated with 100 ml of ground water, zinc sulphate, urea and polluted water, after the interval of a day through drip irrigation system.

Data Recording and Analysis

The main objective of the research work was to observe the effect of different treatment i.e. zinc sulphate, urea and polluted water on the development of chili. Zinc sulphate contain zinc that is very important element for better crop production, similarly urea contains 46% nitrogen that show positive response, while polluted water on the other hand contains heavy metals that are unfit for the plant development and for soil also. Data were recorded time to time and results show different growth patterns under different treatments.

Figure 1: *Variety I of Chilli that Represents the Height of Whole Plant, Number of Leaves, Fresh Weight, and Dry Weight under Different Supplements*

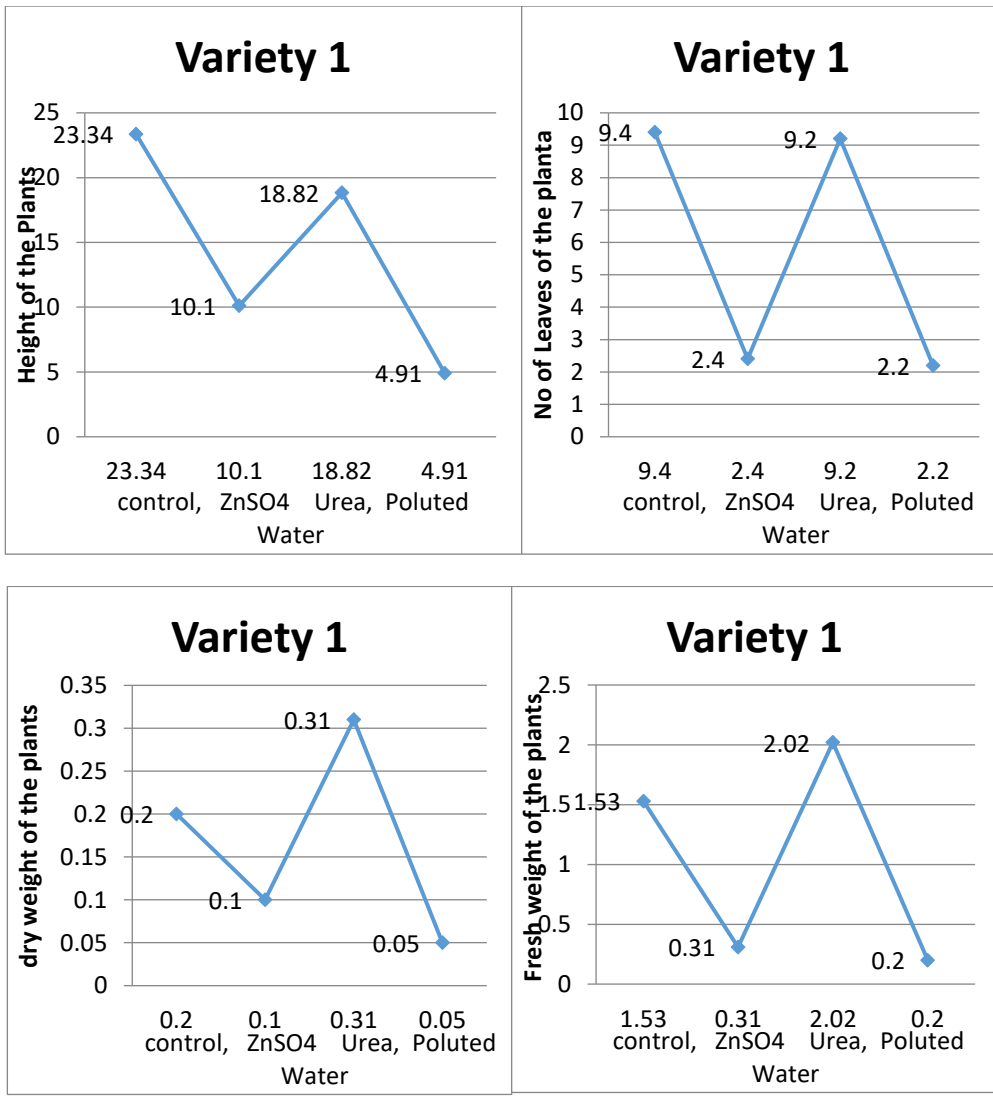
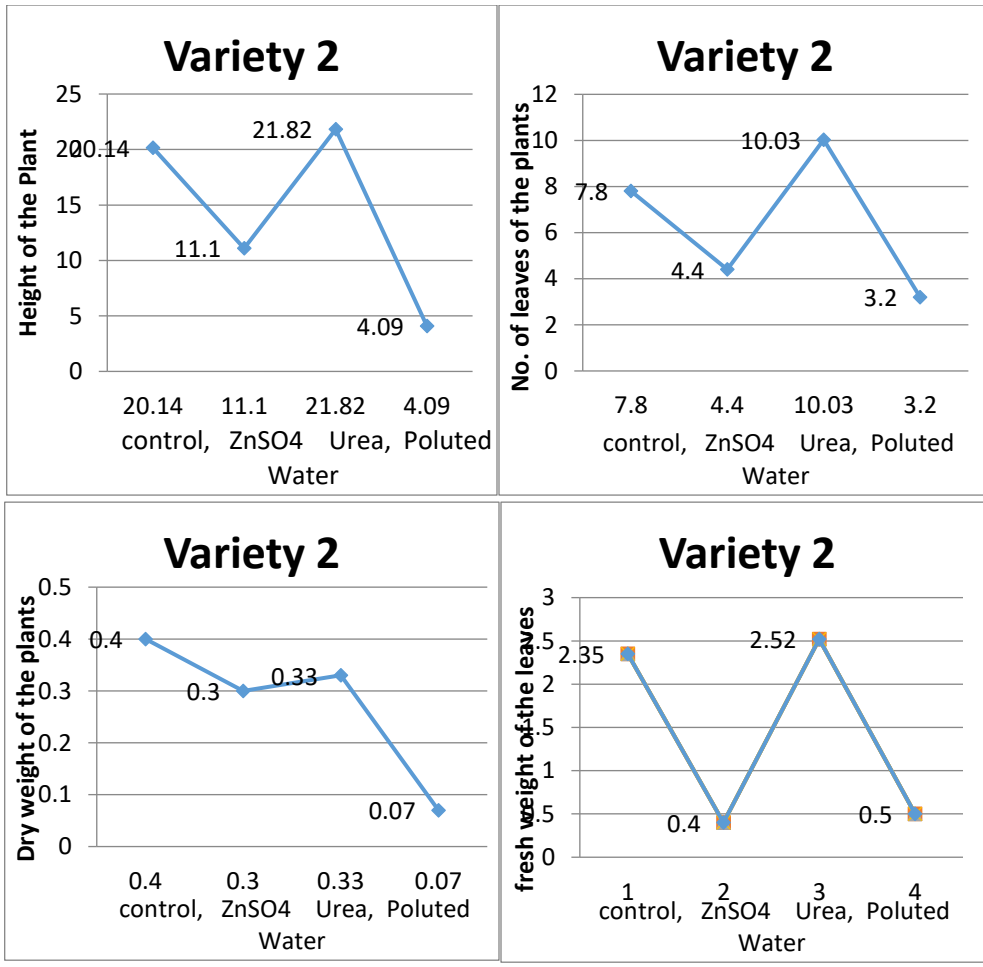


Figure 2: *Variety II of Chilli that Represents the Length of Whole Plant, Number of Leaves, Fresh Weight, and Dry Weight under Different Supplements*



Figures represents the variations during different supplements, soil was already nutrition rich that because growth in control is very good, urea has nitrogen that shows high yields and here in our results urea showed maximum growth in plant height, leaves number and fresh, dry weight after control. Zinc sulphate was applied in more quantity that because here in graph showed minimum growth in all parameters. Polluted water contains heavy metals that retarded the crop growth and development.

Discussion and Conclusion

Drip Irrigation

Drip irrigation significantly increased chilli crop yields compared to the flood irrigation method, showing up to a 60% improvement. This system also resulted in the highest water savings, reduced weed growth, lower disease incidence, and shorter irrigation time (Pandey et al., 2013). Water and fertilizer are essential inputs for improving crop yield and quality. When delivered through drip irrigation, consistent and crop-specific application of these inputs across different ecological zones is critical (Gireesh et al., 2020).

Studies comparing surface irrigation with drip systems—with and without plastic mulch—demonstrated that using 100-micron Linear Low-Density Polyethylene (LLDPE) mulch on raised beds with drip irrigation produced the best outcomes (Bhardwaj et al., 2018).

As global freshwater resources decline and water use efficiency remains low, water-saving irrigation methods have gained importance in agriculture. Research has examined the effects of partial root-zone drip irrigation on productivity and water efficiency (Shu et al., 2020). One study found that plants receiving 50 ml/day through drip irrigation grew most rapidly, although no significant yield difference was noted compared to those treated with organic artificial fertilizer (Andriani et al., 2018).

In Pakistan, drip irrigation has long proven beneficial for fruit and vegetable cultivation. However, its widespread adoption is hindered by the high initial setup cost for small-scale farmers, largely due to system overdesign. Water use efficiency under drip irrigation ranged from 3.91 to 13.30 kg/m³, significantly higher than 1.28 to 4.89 kg/m³ observed in furrow systems. Additionally, drip irrigation enhanced both the physical and chemical quality of produce. Studies have shown that low-cost drip systems can increase yields by over 20% compared to conventional furrow irrigation, offering a viable solution for smallholders (Aziz et al., 2021).

The quality of irrigation water also affects crop yield. Although tertiary, treated, and secondary treated wastewater often exceeded microbial safety limits, no contamination of crops or soil was found at harvest time (Lonigro et al., 2016). Moreover, subsurface drip irrigation reduced cadmium (Cd) content in plant roots, shoots, and fruits, improved yield, and promoted root development within 20–40 cm soil depth. While Cd levels in the rhizosphere were not significantly lowered, this method enhanced microbial populations, root enzyme activities, and enzyme functions in plant leaves and roots (Liu et al., 2021).

Polluted water

Data analysis showed that plant growth parameters and chilli production rose considerably in wastewater treatment with nitrogen and phosphorus application compared to groundwater treatments. It was also shown that the combining more fertilizers with wastewater reduces plant growth and development in chili *(Capsicum annuum L)* plant. Thus, it was established that wastewater reuse as a nutrient source not only to overcomes the difficulties associated with the increased use of different chemical fertilizers, but also reduces fresh water shortage in agricultural land (Chalkoo et al., 2014).

The contamination in polluted and wastewater can be best cope by the interaction of potential plant growth promoting rhizobacteria for plant growth. Under severe metal stress in water and soil, several growth characteristics of chilli plants were lowered. In contrast, cadmium (Cd) and led (Pb) tolerant plant grown promoting rhizobactor inoculation in root related soil improved plant growth development in heavy metal polluted soil and water tests. As a result, these plant growths promoting rhizobactria may be simply employed as bio-fertilizers in mitigating the negative effects of heavy metals on plant development and growth (Pal et al., 2018). Toxic metals and organic compounds present in polluted water negatively affect the growth of plant but its use as a fertilizer not yet studied (Singh & Rathore, 2021).

Different metal accumulation and transport was detected in certain vegetable plant species due to the use of polluted water which also negatively effect on plant vegetative and growth traits. Metal buildup in the roots and top of vegetables varied greatly in proportion to soil metal concentration and plant genotypes (Tiwari et al., 2011). Our results correlate with the above finding that polluted water has negative effect on the plant growth because according to them heavy metals are presents in polluted water.

Urea and Zinc Sulphate

The application of fertilizers, gibberellic acid (GA3), and their combinations significantly influenced five seedling traits in chili: plant height (PH), stem girth (PG), plant spread (PS), number of leaves (NOF), and root length (RL). The study demonstrated enhanced growth and improved morphology in chili seedlings as a result of various fertilizer treatments (Fatima et al., 2024). Incorporating different biofertilizers also led to notable improvements in plant height, stem thickness, leaf size (both length and width), chlorophyll content, fruit yield, soluble sugars, ascorbic and organic acid levels, soil urease and catalase enzyme activities, and the abundance and diversity of beneficial soil bacteria (Gou et al., 2020).

The highest values for all measured parameters were observed with the combined application of 1% urea and 75 ppm NAA (naphthalene acetic acid). This treatment significantly enhanced traits such as plant height, number of leaves, branches, and flowers per plant, leaf width, shoot length, individual and total fruit weight, fruit length and breadth, fruit count per plant, yield per plant, and yield per hectare. In contrast, the lowest values were consistently recorded in untreated or independently treated samples, highlighting the synergistic effect of combined urea and NAA use (Aashish et al., 2022).

Sustainable agricultural practices promote the use of organic fertilizers to enhance the growth, productivity, and quality of vegetables. However, different vegetables respond uniquely to organic fertilizers, leading to varying growth and development outcomes (Bilal et al., 2019).

Zinc (Zn) is a crucial micronutrient that not only supports plant growth but also enhances disease resistance and has antifungal properties. This study assessed both the in-vitro impact of $ZnSO_4$ on the fungal pathogen Alternaria alternata and the in-vivo effects of foliar-applied $ZnSO_4$ on chili pepper plants under disease stress. Foliar application of Zn at 0.036 mM effectively induced resistance in chili plants by boosting antioxidant enzymes (CAT and POX) and defense-related compounds (PPO and PAL), controlling up to 77% of the disease. The findings suggest that foliar $ZnSO_4$ is a promising and sustainable approach to managing Alternaria leaf spot in chili cultivation (Shoaib et al., 2021).

Micronutrients like boron and zinc are essential for plant development, nutrition, and survival. Their application has been shown to enhance the growth, yield, and quality of various crops, including tomatoes, chilies, and others. Specifically, zinc application promotes both vegetative and reproductive development, leading to significantly higher yields. For chilies, zinc applied at concentrations between 0.5% and 0.75% resulted in marked yield improvements. Similar benefits were observed in crops like bottle gourd, broccoli, and okra. Overall, the review confirms that applying boron and zinc to vegetables provides substantial agronomic and economic benefits (Yadav & Kumar, 2023).

We expect that foliar application of humic acid and zinc sulfate ($ZnSO_4$) can be regarded a most effective technique for improving nutrition and secondary metabolite synthesis in medicinal plants (Kazemi et al., 2023). The most effective treatments for improving solanaceae based fruit development, yield, and economic return are foliar applications of potassium sulphate (0.75%), boric acid (400 ppm), and zinc sulphate (400 ppm). The total soluble solid, ascorbic acid, and total sugar

levels increased dramatically as the zinc sulphate levels and number of sprays increased at alternative ranges (Nagar et al., 2021).

The application of varying concentrations of zinc and boron, both individually and in combination, showed a significant positive effect on the growth and yield of chili plants compared to untreated controls. The most effective treatment was the combined foliar application of 0.75% zinc and 0.25% boron, applied twice—once at 45 days and again at 65 days after transplanting—which resulted in the highest green and dry yields. Additionally, foliar spraying with 0.75% zinc alone also significantly enhanced plant growth and yield (Kumar et al., 2020). These findings suggest that foliar application of zinc and boron at a rate of 3 kg per hectare is optimal for promoting robust growth and maximizing chili yield under specific agro-climatic conditions (Khan et al., 2022).

Chilli morpho-phenological characteristics, quality, and various yield parameters were influenced by micronutrients and bioinoculants. Individual applications of micronutrient ($ZnSO_4$ - 0.2%) and their interaction were shown to be beneficial in obtaining maximum output and superior development (Singh et al., 2022). The application of 100% $ZnSO_4$, and 25% nitrogen as the foliar spray through Nano urea method showed the most effective results in terms of plant height (99.69 cm), number of primary branches (8.18 branches), and early flowering and maturing . All growth and vegetative traits positively increased by the application of zinc sulphate (Chauhan & Hu, 2023). Zinc application showed positive impact on plant growth yield and quality (Mondal & Ghosh, 2023).

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