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EVALUATION OF THE DIFFERENT MICRONUTRIENTS AND THEIR METHODS OF APPLICATION ON CROP GROWTH RATE AND RELATIVE GROWTH RATE OF WHEAT CROP

Jay Nath Patel[1]*, Mohd Shah Alam[1], Roop Kishor Pachauri[2], Sandeep Kumar Verma[1], Vivek Pandey[3], Subedar Singh[4], Pramod Kumar[5], Mukesh Kumar[1] and Adesh Singh[1]

[1]Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250 110, U.P.

[2]School of Advanced Agriculture Sciences and Technology, CSJM University, Kanpur, U.P.

[3]Department of Agriculture, Invertis University, Bareilly-243123, U.P.

[4]Motherhood University, Roorkee, Haridwar- 247661, Uttarakhand

[5]Department of Soil Science & Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250 110, U.P.

*Corresponding author E-mail: pateljaynduat333@gmail.com

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ABSTRACT

A two-year field experiment was conducted at Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut to evaluate the impacts of various micronutrients and their application methods on the crop growth rate and relative growth rate of wheat crop. The experiment was laid out in factorial randomized block design with two factors and three replications. The factors used in experiment were four application methods consisting Soil Application, Seed Priming, Foliar Application and Seed Priming + Foliar Application and three micronutrients consisting manganese (Mn), zinc (Zn) and boron (B). The results revealed that among the application methods, Seed Priming + Foliar Application method produced the maximum crop growth rate of wheat during 30-60 DAS and 60-90 DAS and it was statistically at par with Seed Priming and Foliar Application methods during the 60-90 DAS, while, it was non-significant during 90 DAS-At harvest stages. However, the maximum relative growth rate of wheat crop was recorded with Seed Priming + Foliar Application method during 30-60 DAS and under Foliar Application method during 60-90 DAS, whereas, it was non-significant during 90 DAS-At harvest stage of wheat crop during both the years of experiment. Out of the micronutrients, the application of Mn produced the maximum crop growth rate of wheat crop during 30-60 DAS and 60-90 DAS and it was statistically on par with Zn application during the 60-90 DAS, but it was non-significant during 90 DAS-At harvest stage during both experimental years. Whereas, the maximum relative growth rate of wheat crop was noted by application of Mn during 30-60 DAS and with Zn application during 60-90 DAS, however, it was non-significant during 90 DAS-At harvest stages.

***Keywords* :** Wheat, seed priming, micronutrients priming, CGR and RGR.

Introduction

Wheat is one of the most significant and ancient among the cereal crops. The most significant variety among the thousands of known types is common wheat (*Triticum aestivum*), which is used to make bread. Wheat is a major source of carbohydrates and energy and it has less fat. It is the principal source of vegetable protein in human cuisine worldwide, with a protein content of about 13%, which is very high when compared to other main cereals. It also contains a good amount of iron, calcium, thiamine, niacin, riboflavin and other vitamins and minerals. When eaten whole, wheat provides a variety of nutrients and dietary fiber (Shewry and Hey, 2015).

Since 1960, the world's output of wheat and other grain crops has tripled and growth is predicted to continue through the middle of the twenty-first century. Wheat is the most extensively grown and consumed food crop in the world, providing a staple meal for a big global population. India occupied the 31.13 million hectares area, 109.59 million tonnes production, 3521 kg. ha^{-1} productivity in year 2020-21, which shows the significance of wheat crop in our country. Uttar Pradesh occupied the highest area and production (9.85 million hectares and 35.51 million tonnes, respectively) of wheat and followed by the Madhya Pradesh (6.08 million hectares and 18.18 million tonnes, respectively) and Punjab (3.53 million hectares and 17.19 million tonnes, respectively). However, Punjab, Haryana and Rajasthan recorded the maximum productivity of wheat (4868, 4834 and 3676 kg ha^{-1}, respectively) in 2020-21 in India (Anonymous, 2022).

The crop growth rate (CGR) and relative growth rate (RGR) are crucial indicators of the plant production and their health. Crop growth rate measures the increase in biological mass of plant or yield over time, usually per unit area, which helps in assessing that how quickly a crop accumulates biomass in a specific environment. It is an important parameter in agricultural management for the optimization in plant population and resource allocation. Whereas, the relative growth rate determines the rate of growth, relative to the existing biomass and frequently shows the efficiency of a plant to produce new tissues from the resources. Because it emphasizes efficiency and adaptability, relative growth rate is especially helpful for comparing growth rates among species or genotypes under various environmental situations. When taken as a whole, CGR and RGR provide information on how climate, water availability and nutrients affect performance of the crops, which allow the more focused interventions to increase sustainability and yield.

Micronutrients are essential for sustainable agricultural production in India. Numerous studies have shown that, even while micronutrients are only needed in minimal amounts, they significantly increase the effectiveness of using NPK (Shukla *et al*., 2009). Micronutrients have a major impact on dry matter, grain production and straw yield in wheat (Asad and Rafique, 2000). Singh *et al*., (2005) stated that one of the widest ranging abiotic stresses in world agriculture arises from low zinc availability in calcareous soils, particularly in cereals. Zinc insufficient amount, which influences all other micronutrients, is the most prevalent micronutrient issue among different crops (Naik and Das, 2008). However, an essential element that promotes metabolic processes in a number of plant cell compartments is manganese (Mn). Manganese superoxide dismutase (MnSODs), which is found in mitochondria, and the peroxisome both require manganese as a cofactor (Bowler *et al*., 1994; Corpas *et al*., 2017). Protein glycosylation and the synthesis of pectin and hemicellulose polymers depend on manganese since it is required for the activity of several Golgi-localized glycosyltransferases (Strasser *et al*., 2007; Basu *et al*., 2015). Boron deficiency is a major reason of the yield loss of wheat crop (Srivastava *et al*., 2000; Subedi *et al*., 1998). During the reproductive stage, foliar spray of boron enhanced the grain yield of wheat crop (Wroble, 2009), whereas, the lack of boron during the reproductive stage may result in wheat male sterility (Jamjod and Rerkasem, 1999), poor grain set per ear, numerous florets lacking the fertility and shorter anthers (Soleimani, 2006; Chaudry *et al*., 2007).

Wheat crop can be fertilized through different application methods, such as- soil application, foliar application and seed priming. The most often used technique for fertilizing crops is soil application. According to Savithri *et al*. (1999) and Wilhelm *et al*. (1988), foliar spray of micronutrient has been effective in meeting the objectives of fertilizer applications. Foliar spraying is a more effective method of administering micronutrients than soil application for treating the problem of deficiency (Torun *et al*., 2001). Research has shown that immersing seeds in water prior to planting can accelerate the emergence of seedlings and boost their overall health (Harris, 1996).

The aforementioned information clearly shows the importance of the wheat crop for a major human population and the relationship of crop growth rate and relative growth rate with the plants to their yield of the crops is the main background objective of this field study.

Materials and Methods

This field experiment was laid out at CRC farm of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, U.P., India during *rabi* seasons of 2020-21 and 2021-22. The tested variety of wheat crop which was used in this two-years experiment was Karan Narendra (DBW 222). DBW 222 variety is noted for its high potential yield of 82.1 q ha^{-1} and an average yield of 61.3 q ha^{-1} under optimal fertility conditions when sown on time in North India. It demonstrates superior agronomic characteristics, including adaptability to various sowing times, strong rust resistance, desirable quality attributes, and improved lodging tolerance due to a shorter second internode and wider stem diameter. The soils of the field, where both field experiments were conducted are sandy loam, slightly alkaline, low in organic carbon and available nitrogen, normal in electrical conductivity, sufficient in zinc and boron, medium in phosphorus and potassium and deficient in manganese. The experiment was conducted in Factorial RBD design with two factors and three replications. The factors used in experiment were four application methods which comprised of Soil Application, Seed Priming, Foliar Application and Seed Priming + Foliar Application and three micronutrients *viz.*- manganese (Mn), zinc (Zn) and boron (B). Doses of the zinc, manganese and boron for Soil Application were 5, 3 and 1 kg ha^{-1}, respectively. The molar (M) solutions of the zinc (0.5 M), manganese (0.1 M) and boron (0.01 M) were used for Seed Priming of wheat seeds. However, concentration of zinc, manganese and boron for Foliar Application were 0.5%, 0.5% and 0.2% solution, respectively. Foliar Application of different micronutrients were done at two growth stages of wheat crop *i.e.*- booting and anthesis stage in sole application, whereas, when Seed Priming + Foliar Application were performed, foliar application of micronutrients was done only at anthesis stage of wheat crop with mentioned concentration. Whereas, an equal amount of recommended doses of nitrogen, phosphorus and potassium were given to every plots during experiment. The data regarding crop growth rate and relative growth rate of wheat crop was calculated as follow:

Crop growth rate (g day^{-1}): - At 30, 60, 90 DAS, and at harvest stages, the dry weight of the plants (m^2) in each plot was noted and the crop growth rate was then determined using the following formula:

$$\text{Crop growth rate (CGR)} = \frac{W_2 - W_1}{T_2 - T_1}$$

Relative growth rate (mg g^{-1} day^{-1}): - The following formula was used to get the relative growth rate:

$$\text{Relative growth rate (RGR)} = \frac{\text{Ln}(W_2) - \text{Ln}(W_1)}{T_2 - T_1}$$

Where, W_1= Dry weight (30, 60 and 90 DAS), W_2 = Dry weight (60, 90 DAS and at harvest), T_1 and T_2 are the time interval in days and Ln= Natural Log.

Results

Crop growth rate

The data regarding to the crop growth rates of the wheat crop during the two-years of experiment are presented in Table-1 and depicted in Figure-1. The study of the data revealed that the various micronutrients and their methods of application significantly affected the crop growth rate of wheat crop during both the years of experiment.

Table 1: Effects of micronutrients and their application modes on crop growth rate (g m^{-2} day^{-1}) of wheat crop during various stages

Treatments	Crop growth rate (g m^{-2} day^{-1})					
	30-60 DAS		60-90 DAS		90 DAS-At harvest	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Application modes						
Soil Application	9.49	9.16	14.26	14.16	11.18	11.15
Seed Priming	10.53	10.40	15.38	15.31	11.32	11.29
Foliar Application	9.80	9.46	14.79	14.70	11.19	11.32
Seed Priming + Foliar Application	11.15	11.00	15.64	15.52	11.25	11.24
SEm+	*0.04*	*0.04*	*0.32*	*0.31*	*0.68*	*0.68*
CD (P= 0.05)	*0.13*	*0.12*	*0.93*	*0.92*	*NS*	*NS*
Micronutrients						
Zinc	10.33	10.09	14.89	14.80	11.12	11.28
Manganese	10.84	10.61	15.59	15.47	11.18	11.17
Boron	9.55	9.31	14.58	14.50	11.12	11.28
SEm+	*0.03*	*0.04*	*0.27*	*0.26*	*0.59*	*0.58*
CD (P= 0.05)	*0.12*	*0.10*	*0.81*	*0.80*	*NS*	*NS*

Further analysis of the data showed that among the application methods, the Seed Priming + Foliar Application method produced the maximum crop growth rate of wheat crop during 30-60 DAS and 60-90 DAS stages and it was statistically at par with Seed Priming and Foliar Application during the 60-90 DAS stages, while, it was non-significant during 90 DAS-At harvest stages during both experimental years. However, the minimum crop growth rate of wheat crop was noted with Soil Application method during all stages in both years of experiments.

Among the micronutrients, application of Mn produced the maximum crop growth rate of wheat crop during 30-60 DAS and 60-90 DAS stages and it was statistically on par with Zn application during the 60-90 DAS, while, it was non-significant during 90 DAS-At harvest during both experimental years. Whereas, the minimum crop growth rate of wheat crop was noted with the application of B in both years of experiment during 30-60 DAS and 60-90 DAS stages, while, during 90 DAS-At harvest stages, B and Zn application produced similar minimum crop growth rate in first year, but in second year Mn produced minimum crop growth rate of wheat crop.

Relative growth rate

The combined data pertaining to the relative growth rate of the wheat crop during the course of the two-year experiment are shown in Table-2 and Figure-2. The examination of the data showed that, in both experimental years, the relative growth rate of the wheat crop was significantly impacted by the different micronutrients and their methods of application.

The further analysis of the data revealed that among application methods, the maximum relative growth rate of wheat crop was recorded with Seed Priming + Foliar Application method during 30-60 DAS stages and with Foliar Application method during 60-90 DAS stages, whereas, it was non-significant during the 90 DAS-At harvest stages of wheat crop during both years of experiment. However, the minimum relative growth rate of the wheat crop was noted with Soil Application method in both two-years of experiment during 30-60 DAS stages, while, Seed Priming + Foliar Application method produced the minimum relative growth rate of the wheat crop during 60-90 DAS and 90 DAS-At harvest stages in both experimental years.

Table 2: Effects of micronutrients and their application modes on relative growth rate (mg g^{-1} day^{-1}) of wheat crop during various stages

Treatments	Relative growth rate (RGR) (mg g^{-1} day^{-1})					
	30-60 DAS		60-90 DAS		90 DAS-At harvest	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Application modes						
Soil Application	59.91	60.81	27.00	27.07	12.06	12.13
Seed Priming	61.76	61.67	26.45	26.67	11.16	11.31
Foliar Application	61.66	62.56	27.20	27.36	11.84	11.99
Seed Priming + Foliar Application	62.77	62.84	25.95	26.03	10.93	11.07
SEm+	*0.04*	*0.02*	*0.01*	*0.02*	*0.92*	*0.75*
CD (P= 0.05)	*0.11*	*0.05*	*0.03*	*0.04*	*NS*	*NS*
Micronutrients						
Zinc	61.89	62.31	27.25	27.43	11.90	12.12
Manganese	62.01	62.50	26.38	26.43	11.13	11.10
Boron	60.67	61.10	26.32	26.48	11.46	11.67
Sem+	*0.03*	*0.01*	*0.01*	*0.01*	*0.80*	*0.65*
CD (P= 0.05)	*0.10*	*0.04*	*0.02*	*0.04*	*NS*	*NS*

Out of the Micronutrients, the maximum relative growth rate of wheat crop was produced by application of Mn during 30-60 DAS stages and with Zn application during 60-90 DAS stages, however, it was non-significant during 90 DAS-At harvest during both two-years of the field experiment. Whereas, the minimum relative growth rate of wheat crop was recorded with the application of B in both experimental years during 30-60 DAS stages and in first year during 60-90 DAS, while, in second year during 60-90 DAS stages and in both years of experiment during 90 DAS-At harvest stages the Mn produced the minimal relative growth rate of the wheat crop.

Discussion

Application of manganese and zinc through the Seed Priming and Foliar Application methods produced the maximum crop growth rates and relative growth rates of wheat crop during two-year field experiments. It might be due to the seed priming and foliar application with micronutrients can significantly enhanced the nutrient uptake, metabolic activities and enzymatic functions, leading to improved germination rates, early seedling vigour and overall crop performance which might increase the dry matter production of wheat crop and it enhanced the crop growth rate and relative growth rates of wheat crop during different stages. Seed priming with manganese can have a significant impact on the growth rate of wheat crops. Manganese is an essential micronutrient involved in various physiological processes crucial for plant growth and development. Kaur *et al.* (2020) revealed that the application of zinc and foliar spray of manganese resulted in the higher dry matter accumulation of wheat crop. Neha *et al.* (2017) also found that the application of Zn @10 kg ha^{-1} recorded the higher dry matter accumulation of wheat crop at maximum tillering and harvest stage, respectively. Arif *et al.* (2019) investigated that the application of zinc through the soil application + $ZnSO_4$ 0.5% foliar spray highest dry matter accumulation. Overall, seed priming with micronutrients offers a targeted and efficient approach to enhancing the crop growth rate of wheat crop and foliar application of micronutrients can significantly affect the chlorophyll content of wheat crops by promoting chlorophyll synthesis, enhancing photosynthetic efficiency, mitigating stress effects, stimulating leaf expansion and these combined effects contribute to improve the growth and development of wheat crop ultimately.

Conclusions

The application of micronutrients and their delivery methods had significant impacts on the crop growth rate and relative growth rate at various stages of wheat crop during the two-years of this field experiment. Among the application methods, the Seed Priming + Foliar Application method recorded the maximum crop growth rate and relative growth rate of the wheat crop between 30-60 DAS and 60-90 DAS in both years of experiment. However, out of the micronutrients, the application of Mn produced the maximum crop growth rate of the wheat crop in between 30-60 DAS and 60-90 DAS and relative growth rate during 30-60 DAS and Zn application noted the highest relative growth rate of wheat crop between 60-90 DAS stage during both experimental years. However, the data of crop growth rate and relative growth rate of the wheat crop were found statistically non-significant during 90 DAS-At harvest stage of the wheat crop during both two-years of the field investigations.

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