RESPONSE OF *TRITICUM AESTIVUM L.* TO EXOGENOUS APPLICATION OF PLANT GROWTH REGULATORS

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Abstract

This research was conducted to evaluate the effect of zinc, proline, and biostimulant foliar application on yield of wheat. The trial was established in the research farm of the Department of Agronomy, Bahauddin Zakariya University, Multan, Pakistan. A randomized complete block design was used with three replicates. All three treatments were sprayed on *Triticum aestivum* cv. Galaxy at the booting stage and results of yield were compared with control. One way analysis of variance revealed that all treatments affected wheat yield significantly. Zinc foliar application (4 m*M* solution) produced tallest plants (104 cm), longest spikes (13 cm), maximum biological yield (2.76 kg m^{-2}), and heaviest 1000 grains (45.2 g). While the maximum number of grains per plant (72) and maximum grain (602 g m^{-2}) yield was observed for biostimulant sprayed at a rate of 1.2 l ha^{-1} on wheat. Pearson correlation also revealed a positive correlation among yield components except for plant height and grain yield that were negatively correlated. The results revealed that foliar application of zinc, proline, and biostimulant can be used to improve yield components of wheat particularly zinc application that produced better biological and economical yield.

Keywords: Wheat; yield enhancements; foliar application; biostimulant; proline; zinc

Összefoglalás

A munkánkban a cink, a prolin és egy biostimulátor levélen keresztüli alkalmazásának a tavaszi búza termésére gyakorolt hatását vizsgáltuk. A kísérletet a Bahauddin Zakariya Egyetem Növénytermesztési Tanszékén vizsgáltuk Multan városban, Pakisztánban. A kísérletet teljes véletlen blokk elrendezésben állítottuk be 3 ismétléssel. Mindhárom kezelést a Galaxy tavaszi búza (*Triticum aestivum L.*) fajtán végeztük el lombra permetezéssel kalászhányás kezdetén és a kontrolhoz hasonlítva vizsgáltuk a kezelések terméselemekre gyakorolt hatását. Az egytényezős varianciaanalízis eredménye mindhárom kezelés esetében szignifikáns hatást mutatott. A cink levélen keresztüli alkalmazása (4 m*M* oldat) eredményezte a legnagyobb növénymagasságot (104 cm), a legnagyobb kalászhosszúságot (13 cm), a maximális biomassza termést (2.76 kg m^{-2}) és a legmagasabb ezerszem tömeget (45.2 g). Ezzel szemben a növényenkénti maximális szemszám (72) és a legmagasabb szemtermés (602 g m^{-2}) a biostimulátor 1.2 l/ha adagjának alkalmazása esetén volt megfigyelhető. Pearson korreláció a terméselemek között a növénymagasságot és a szemtermést kivéve negatív összefüggést mutatott. Az eredmények alátámasztják, hogy a cink a prolin és a biostimulátor alkalmazásával javíthatóak az őszi búza terméselemei, különösen a cink alkalmazásával, ami magasabb összbiomassza tömeget és szemtermést eredményezett.

Kulcsszavak: búza; termés növelés; lombtrágyázás; biostimulátor; prolin; cink

Introduction

Since 1960, the world population has jumped from 3.1 billion to 6.7 billion making it a challenge for agriculture to feed the population. Due to the green revolution, mechanical, and genetic advancements; cereal production grew faster than the population. Among cereals, wheat is one of the most important cereal being a staple food for a major portion of the population. The increase in wheat production recorded is 3.38% per year in the past but in recent years (after 1990) the wheat production increased by just 0.67% yearly. From 1960-1990 global wheat area increased by 0.43% per year but shrank down to 0.23% per year after 1990. Moreover, a 2.95% yield yearly increase was observed in the period 1960-1990 but later it also reduced to 0.90% per year. Therefore, wheat production has failed to match pace with the global population increase (Pardey, 2011).

Researchers are trying to achieve short term success in improving wheat yield. Several strategies including seed priming (Harris et al., 2002), nutrient foliar spray (Arif et al., 2006), use of plant growth regulators (Griffin and Hollis, 2017), and biostimulant (Al Majathoub, 2004) have been reported to improve wheat yield. Therefore, this research was designed to determine the usefulness and impact of nutrient, plant growth regulator and commercial biostimulant spray on wheat to improve yield per unit area of wheat.

Material and methods

Experimental site and seed material

To evaluate the impact of exogenous foliar application on yield and yield components of wheat; a trial was established at the research farm of Bahauddin Zakariya University, Multan (30.2°N, 71.47°E) Pakistan. Seed material was obtained from the Regional Agriculture Research Institute, Bahawalpur, Pakistan.

Crop Husbandry

The field was irrigated before sowing and allowed the water to infiltrate. Seedbed was prepared by cultivating the field thrice followed by planking. Seeds of *Triticum aestivum L.* cv. *Galaxy* were sown on 15^{th} November 2016 using man pulled drill. Rows were 25 cm apart from each other. Recommended fertilizer (150: 100: 75 Kg ha^{-1} NPK) was used. Diammonium phosphate (DAP) containing 46% P and 18% N was used as the main source of phosphorous. Remaining nitrogen was provided by urea that contains 46% N. While, muriate of potash (MOP) containing potassium chloride (KCL) was used as a source of potassium (K) which contains 60% K. Half of nitrogen and full potassium and phosphorous dose were applied as a basal application while remaining nitrogen was applied at first irrigation. The crop was irrigated at critical stages to avoid moisture stress. Weeds were removed manually after every two weeks and crop was harvested on 10th April 2017.

Treatments and experiment layout

The effect of foliar application of proline, zinc, and a biostimulant on wheat yield and yield components was compared with control. Foliar application of 100 m*M* proline (Talat et al., 2013), 4 m*M* solution of zinc (Aslam et al., 2014), and 1.2 liters ha^{-1} commercial biostimulant3D (Innovative chemicals, Pakistan) was performed at booting stage of wheat. Each treatment was applied to an area of 20 m^2 (5m x 4m) and was replicated thrice. Randomized Complete Block Design was used.

Observations

At harvesting, plants were harvested manually from 2 random points in each plot using a 1 m^2 quadrate. Plant height was measured from ground level to the top of 10 plants from each plot using a measuring tape and was averaged. Spikes of 10 random plants were plucked and their length was also measured using a measuring tape. Grains from these 10 spikes were counted manually and averaged to obtain the number of grains per plant. Later, a thousand seeds from each plot were counted and weighed to get 1000 grain weight. Harvested plants from an area of 2 m^2 were weighed to calculate biological (total biomass) yield (kg m^{-2}) and economic (grain) yield from plants harvested from an area of 2 m^2 were measured to obtain grain yield (g m^{-2}).

Statistical analysis

The collected data was put in MS Excel 2007 to measure standard deviation and to make graphs. SPSS was used for the analysis of variance at 0.05 and 0.01 level of significance and to determine the differences among the means of treatments when compared at a 5% probability level using the LSD test. Pearson correlation among yield components of wheat was also analyzed using SPSS.

Results and discussion

Statistical analysis of treatments effect on yield components showed that the effect of exogenous foliar applications was highly significant ($P<0.01$) on all yield components except 1000 grain weight where the effect was only significant ($P<0.05$) (Table 1).

Table 1. Mean square values and significance of exogenous application on wheat yield components

SOV	df	Plant height (cm)	Spike length (cm)	No. Of grains per plant	Biological yield (g m^{-2})	Economic yield (g m^{-2})	1000 grain weight (g)
Replication	2	30.438	0.8750	22.240	82769	195.1	1.2399
Foliar Application	3	695.008**	13.4351**	332.101**	2030703**	61065.3**	39.3436*
Error	6	13.598	0.4088	11.511	104978	987.2	8.2316

** $P< 0.01$, * $P< 0.05$

Zinc foliar application significantly affected vegetative growth of wheat and produced tallest plants (104 cm) that were statistically at par with proline foliar application (101 cm) followed by biostimulant foliar application (78 cm) (Fig. 1). Similar results were observed for biological yield that was significantly affected by zinc foliar application (2.76 kg m^{-2}) and proline foliar application (2.48 kg m^{-2}) followed by biostimulant foliar application (1.62 kg m^{-2}) (Fig. 2). Longest spikes were also observed for zinc foliar application (13 cm) that was statistically at par with proline foliar application (12 cm) followed by biostimulant foliar application (11 cm) (Fig. 3).

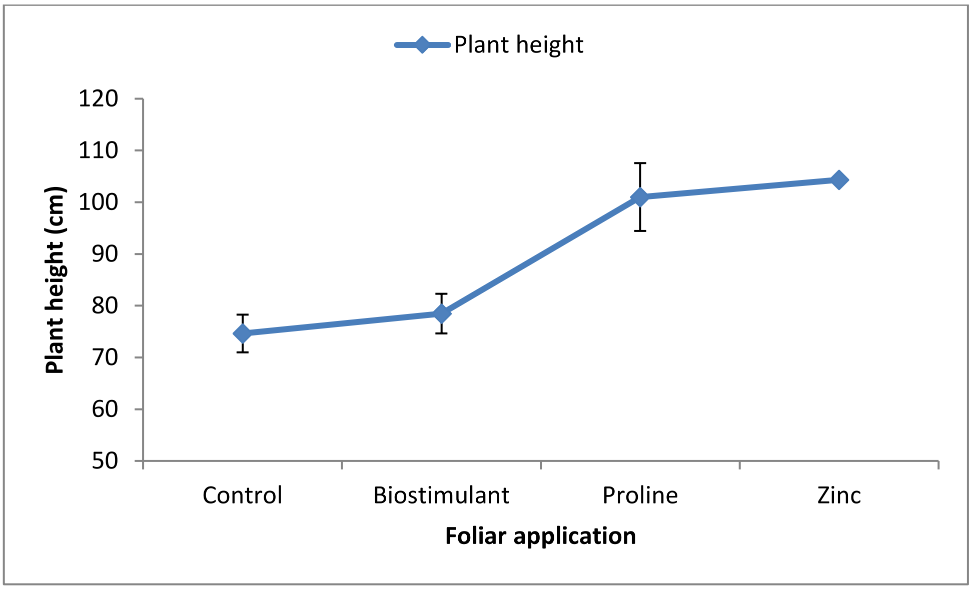

Figure 1. Effect of zinc, proline, and biostimulant foliar application on plant height of wheat

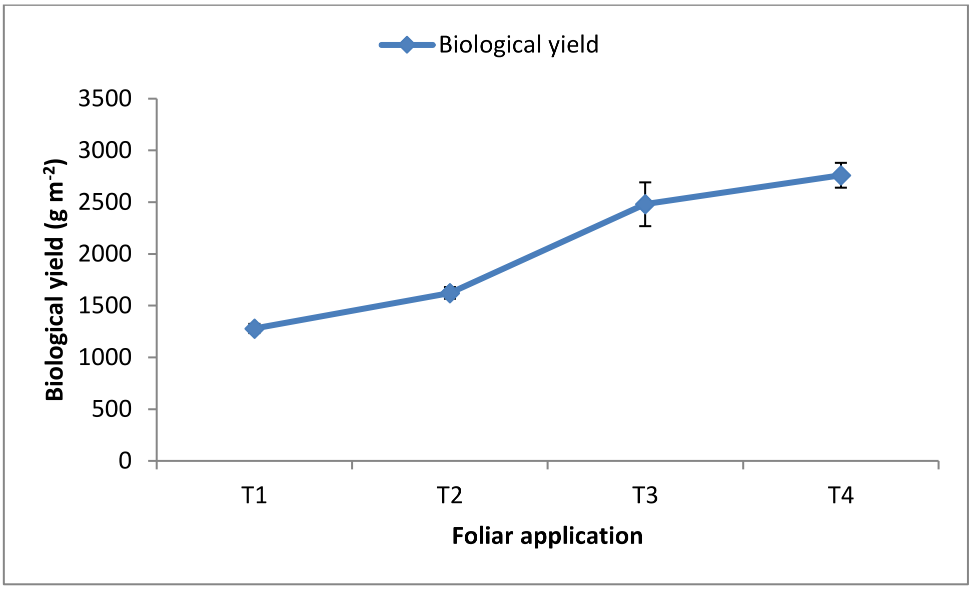

Figure 2. Effect of zinc, proline, and biostimulant foliar application on biological yield of wheat

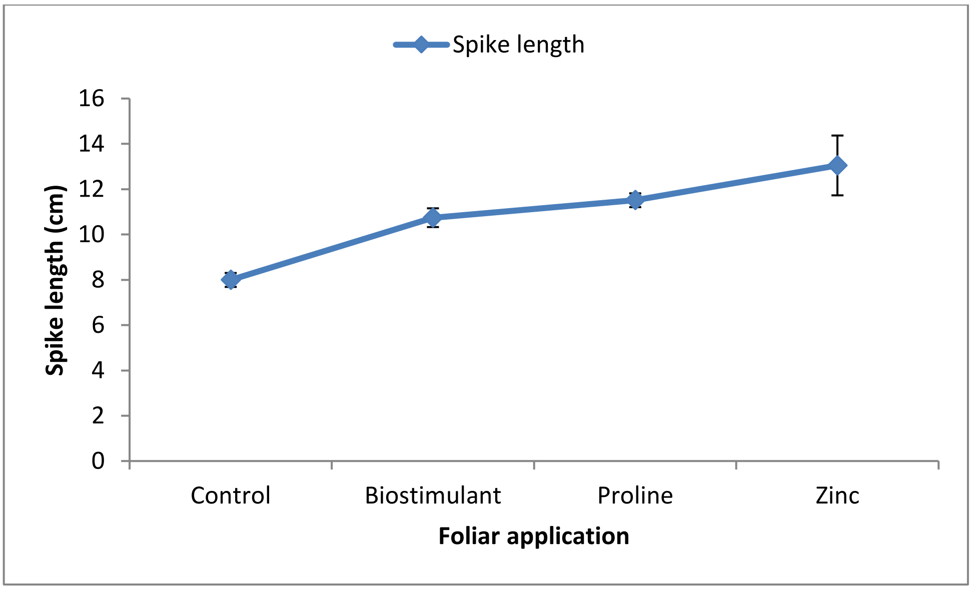

Figure 3. Effect of zinc, proline, and biostimulant foliar application on spike length of wheat

Maximum numbers of grains per plant (72) were observed for biostimulant sprayed plants followed by zinc foliar application (59) that was statistically at par with the other two treatments (Fig. 4). Maximum economic (grain) yield (602 g m^{-2}) was also observed for biostimulant foliar application followed by proline foliar application (424 g m^{-2}) (Fig. 5). Maximum 1000 grain weight was measured for Zn foliar application (45.2 g) followed by biostimulant (42.7 g) that was statistically at par with proline foliar (39.4 g) (Fig. 6).

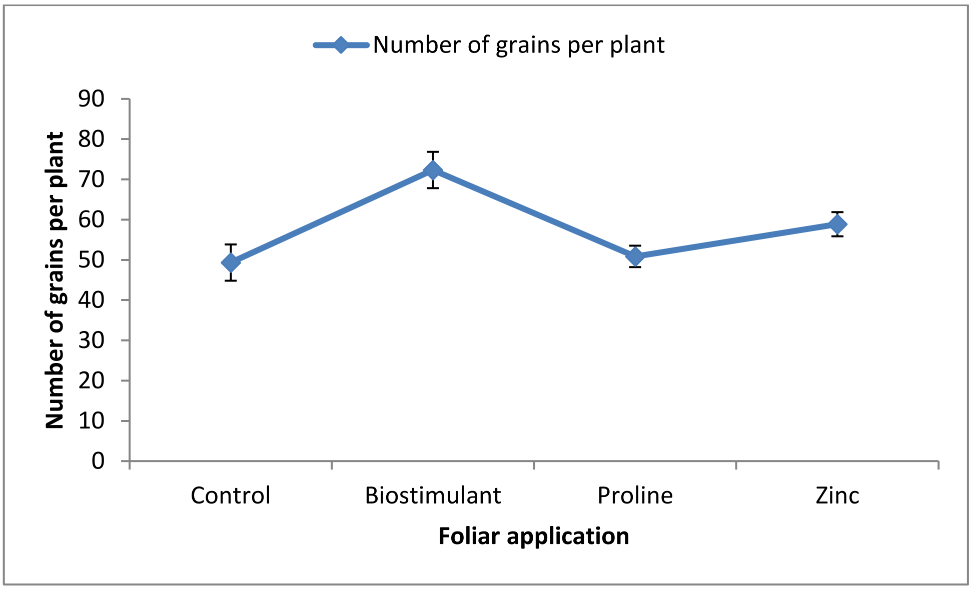

Figure 4. Effect of zinc, proline, and biostimulant foliar application on the number of grains per wheat plant

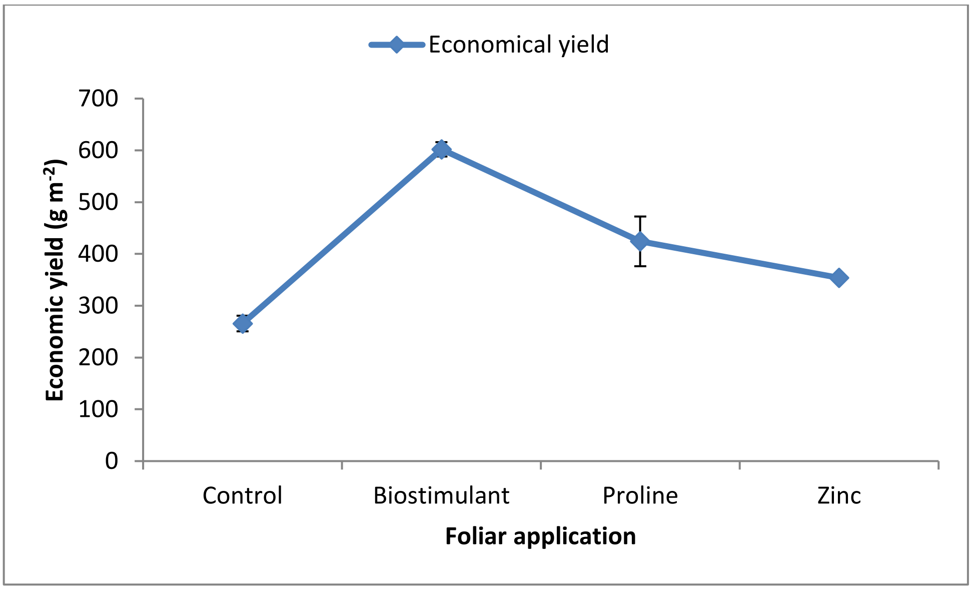

Figure 5. Effect of zinc, proline, and biostimulant foliar application on economic yield of wheat

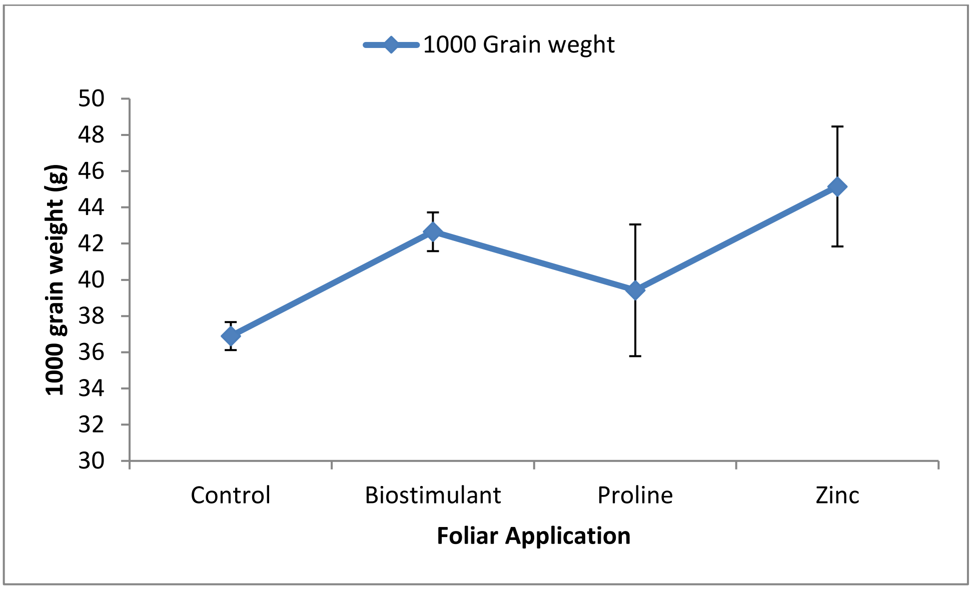

Figure 6. Effect of zinc, proline, and biostimulant foliar application on 1000 grain weight of wheat

The mean comparison of treatments revealed that all foliar applications significantly affected yield components of wheat. Zinc foliar application was found to be most effective as it significantly affected plant height, spike length, biological yield, and 1000 grain weight. Biostimulant foliar application significantly improved economic parts of wheat by producing the most number of grains per plant and maximum economic yield. Proline foliar application also affected plant height significantly and was statistically at par with zinc foliar application for spike length, biological yield, and 1000 grain weight (Table 2).

Table 2. Mean comparison of exogenous application on yield components of wheat

Treatment	Plant height (cm)	Spike length (cm)	No. of grains per plant	Biological yield (g m^{-2})	Economic yield (g m^{-2})	1000 grain weight (g)
Control	74.63b	7.993c	49.333b	1279.3c	265.67c	36.892b
Biostimulant	78.47b	10.740b	72.333a	1623.0bc	602.00a	42.652ab
Proline	101.00a	11.510ab	50.867b	2480.0ab	424.27b	39.420ab
Zinc	104.33a	13.047a	58.867b	3093.3a	353.67bc	45.153a

Mean having similar letters within a column do not differ statistically

Pearson correlation analysis showed that yield components are positively related to each other. Biological yield is significantly correlated to plant height and spike length at 0.001 levels and to 1000 grain weight at 0.05 levels. Plant height is positively correlated to spike length; however, it is negatively correlated to economic yield at 0.01 levels. The number of grains per spike is correlated to economic yield at 0.01 levels of significance (Table 3).

Table 3. Correlations among yield determining factors of wheat

Correlations

	Biological Yield	**Plant height**	**Spike length**	**Number of grains per plant**	**Economic yield**	**1000 grain weight**
Biological Yield	1					
Plant height	0.858**	1				
Spike length	0.750**	0.777**	1			
Number of grains per plant	-0.071	-0.226	0.344	1		
Economic yield	-0.506	-0.726**	-0.319	0.754**	1	
1000 grain weight	0.644*	0.407	0.578*	0.483	0.188	1

**. Correlation is significant at the 1% level, *. Correlation is significant at the 5% level

Discussion

Wheat being the staple crop of most developing countries demands to be produced on a larger scale to meet the requirements of the ever-increasing population. According to an estimate, the population has jumped from 3.1 billion to 6.7 billion while wheat production is increasing at a passive rate which is not enough to feed the population (Dixon et al., 2009). Therefore this research was established to assess the effect of exogenous foliar application on yield of wheat. Zinc foliar application improved wheat yield by significantly affecting wheat yield components. An increase of 8.3 g per 1000 grain weight due to zinc was observed and can be attributed to the fact that zinc is a vital part of enzymes and improves enzyme activity to deposit more photosynthates in grain leading to heavier grains (Hotz and Braun, 2004). Similarly, an increase in plant height, spike length, and biological yield due to zinc biofortification was also significant. These results are in line with the results observed by Paul et al., (2016) in which they reported an increase in plant height (4.49 cm), an increase in spike length (1.33 cm), and an increase in 1000 grain weight (3.95 g). Similar results have been reported by several researchers (Abdoli et al., 2014; Sultana et al., 2016; Esfandiari et al., 2016).

Effect of proline foliar application on plant height, spike length, biological yield, and 1000 grain weight was statistically equal or at par with zinc foliar application. Proline is an amino acid that regulates the activity and functioning of antioxidants to develop a better surviving response of plants to the environment (Öztürk and Demir, 2002). Proline at different concentration has been reported to improve growth and yield of *Urtica pilulifera* L. (Wahba et al., 2007), *Matricaria chamomilla* L. (El-Din and El-Wahed, 2005), *and Solanum lycopersicum* L. (Abd El-Latif, 1995; Ragab et al., 2001), *Zea mays* L. (Hamedand Al-Wakeel, 1994), *Nicotiana rustica* L. (Darwish and Reda, 1975), and *Gossypium barbadense* (Heikal and Shaddad, 1982) due to nitrogen content of proline.

Biostimulant (3D) is a mixture of gibberellic acid and naphthalic acid that increased the number of grains per spike, economic yield, and 1000 grain weight. The increased number of grains per spike can be due to elevated transportation of sucrose (Shakirova et al., 2003). The increased 1000 grain weight has also been observed by Al Majathoub, (2004) who reported an influence of better translocation of assimilates leading towards heavier grains and eventually higher economic yield. Similar results were also reported by Naghashzadeh (2007), Wang et al., (1996) and Islam et al., (2014).

Conclusion

It is evident from the results that foliar application of nutrient or plant growth regulators or biostimulants is effective in improving wheat yield and yield parameters. The use of nutrient foliar spray proved to be the most effective treatment followed by plant growth regulator and biostimulant spray. Their use can be advised to farmers facing low yield problem in wheat. Moreover, the combined effect of these treatments can be studied in the future to determine whether they have positive interaction or negative interaction with each other.

Acknowledgment

The work/publication is supported by the EFOP-3.6.3-VEKOP-16-2017-00008 project. The project is co-financed by the European Union and the European Social Fund.

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