Assessment of Plant Growth Promoters on Growth Characteristics, Yield Attributes and Yield of Wheat (*Triticum aestivum* L.) Varieties in Central Plain Zone of Uttar Pradesh

ABSTRACT

The present investigation entitled "Assessment of plant growth promoters on growth characters, yield attributes and yield of wheat varieties (*Triticum aestivum* L.) in central plain zone of U.P." was carried out during *Rabi* season of 2022-23 at Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The experiment was designed with two factors, viz. wheat varieties (DBW-187 and PBW-723) in the main plots and plant growth promoters (PGPs) viz., micronutrients (Zn, Fe, B, Cu) @ 0.5%, nitrobenzene @ 3 ml l^{-1}, gibberellic acid @ 2 ml l^{-1}, seaweed extract liquid @ 625 ml ha^{-1}, seaweed extract solid @ 25 kg ha^{-1}, UPL Macarena (Fermented extract nutrient 15%) @ 625ml ha^{-1}, Humesol (humic acid 18%, fulvic acid 15%) @ 1250 ml ha^{-1}, and Amino Booster G (30% amino acid solution) @ 5 ml l^{-1} were selected in sub-plots. These treatments were compared with a control treatment. The experiment was laid out in a *Split Plot Design* and replicated three times. The results revealed that significant variations were noticed in different treatments. The wheat variety DBW-187 exhibited superior growth and, yield attributes, with a grain yield of 4601.8 kg ha^{-1}, surpassing other variety. Among plant growth promoters the blend of micronutrients (Zn, Fe, B, Cu) @ 0.5% foliar spray at tillering stage resulted in the significantly maximum plant height (86.55 cm), crop growth rate (0.243 g m^{-2} day^{-1}), at 45 to 90 DAS, number of tillers (425.13 m^{-2}) at maturity respectively, grain yield (4572.17 kg ha^{-1}) and straw yield (7072.20 kg ha^{-1}). The gibberellic acid @ 2 ml l^{-1} and seaweed extract liquid @ 625 ml ha^{-1} also showed significant results.

Keywords: Growth promoters, wheat varieties, grain yield, straw yield

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important crops in terms of cultivated area and production rate in the world and plays an important role in providing the food needs of human societies [1]. In India, the total area under wheat is 30.46 million hectares with a production of 104.00 million tonnes and thea productivity of 3.41 tonnes per hectare [2]. It is

UNDER PEER REVIEW

the staple food therefore, to ensure global food security for rapidly growing population, wheat production needs to be doubled by 2050. Soil micro-nutrients, including zinc (Zn), iron (Fe), Boron (B) and copper (Cu) have been found deficit in the majority of soils where intensive agriculture is being practiced and thus pose a serious threat ~~for~~to food production worldwide [3]. About 49% of India's cultivated land is deficient in Zn and Cu [4]. Further long-term soil health and sustained crop productivity cannot be maintained by using sole chemical fertilizers since they do not supply all the required nutrient elements particularly trace elements [5]. Plant growth regulators (PGRs) are one of the solutions to increase the yield of agricultural plants under different stress conditions [6]. It's yield depends on the intensity, genotype, time of application, concentration used, and intensity of the stress level [7]. In the current situation, it is vital to adopt agricultural management methods and the use of PGRs including cytokinins, gibberellic acid (GA3) and~~,~~ seaweed extracts. They ~~has~~have various effects on plants, inducing grain germination, and stimulating the production of important hydrolyzing enzymes in the germination of leguminous grains. [8] certified the alleviating effect of GA3 on plant tolerance to salt stress. CK reduces the adverse effects of non-living stresses and also causes cell division, removal of apical dominance, stem differentiation, and delaying ageing [9]. The opportunity presented by growth promoters is great for improving soil sustainability as well as overall productivity, because of the global energy crisis and the ongoing increase in the cost of artificial ~~fertilisers~~fertilizers. Since growth regulators are employed in the commercial sector to boost wheat yield, it was important to investigate how exogenous bio-stimulants affect the wheat growth process. The totality of a plant's metabolic processes adds up to its yield, which is influenced by several elements that impact the plant's metabolic activity during growth. Materials known as bio-stimulants can ~~have the ability to~~ stimulate plant growth in modest doses. This experiment aimed to implement a new method of nutrient management in relation to plant growth promoters on different wheat varieties, for use in agricultural fields to increase yield.

2. MATERIALS AND METHODS

The field experiment was conducted at Chandra Shekhar Azad University of Agriculture and Technology in Kanpur, Uttar Pradesh during the *rabi* season of 2022-23. Kanpur is geographically located in the central part of Uttar Pradesh, It is positioned at coordinates 26° 29' 35" North latitude and 80° 18' 25" East longitude, with an elevation of approximately 125.9 meters above mean sea level in the Gangetic plain. The weekly maximum mean

UNDER PEER REVIEW

temperature~~,~~ ranged from 13.9°C to 39.2°C and the minimum mean temperature ranged from 4.4°C to 21.8°C during the period of crop growth. The maximum temperature of 39.2°C was recorded in April, whereas the minimum temperature of 4.4°C was observed in January. The t~~T~~otal rainfall received during the crop growth period was 83 mm. Detailed information about the crop weather conditions during the cropping period can be seen in graph provided (Fig. 1). The soil texture of experiment field is characterized as sandy loam, with specific measurements including o~~O~~rganic carbon (0.49%), a~~A~~vailable nitrogen (148.20 kg ha^{-1}), a~~A~~vailable P_2-O_5 (20.60 kg ha^{-1}), a~~A~~vailable K_2O (215.50 kg ha^{-1}), and pH of 7.7. Two timely sown varieties (V1 -DBW-187, V2 –PBW-723) were allocated in the main plots and plant growth promoters (G0 - Control, G1- Nitro benzene @ 3 ml l^{-1}, G2 - Gibberellic acid @ 2 ml l~~L~~ $^{-1}$, G3 - Seaweed extract solid @ 25 kg ha^{-1}, G4 - Seaweed extract liquid @ 625 ml ha^{-1}, G5 - Micronutrients (Zn, Fe, B, Cu) @ 0.5%, G6 - UPL Macarena@ 625ml ha^{-1}, G7 - Humesol @1250 ml ha^{-1}, G8 - Amino Booster G) were allocated in the sub-plots. The experiment was laid out in *Split Plot Design* with three replications. Two varieties namely DBW-187 and PBW-723 were tested in the experiment. The other cultural practices were adopted as recommended packages of practice. The crop was given 4 irrigations at critical stages excluding one pre~~-~~sowing irrigation. Three plants were randomly selected and tagged from each plot for measuring plant height (cm) from the soil surface to the basal portion of the flag leaf using a meter scale at 45 DAS, 90 DAS and at maturity. Number of tillers m^{-2} was calculated by counting total number of tillers in 1m×1m quadrate and expressed in terms of per m^2. Crop growth rate (g m^{-2} day^{-1}) is estimated by calculating the average daily increment of plant biomass per unit time interval. This provides the rate of dry matter production. Number of ears m^{-2} was estimated by counting number of spikes per meter square before harvesting of the crop from four places which were then averaged~~-~~. The ear length (cm) was measured from the neck to the tip of the spike. The number of seeds ear^{-1} was calculated by counting number of filled grains in three random samples and finally, the means were computed. Seed weight per ear (g) was measured from randomly selected tagged ears which were balanced manually from each replication and averaged to get weight (g) of grain per ear. The grain yield was deducted from the biological yield of the corresponding plots to get the straw yield and was expressed as kg ha^{-1}. The data obtained from the experiment were statistically analyzed with the help of analysis of variance (ANOVA) technique for split plot design. The LSD (Least Significant Difference) test was utilized to compare the means of the treatment at a 5% level of probability.

Comment [a1]: Kindly remove this sentence. Already mentioned in above lines.

UNDER PEER REVIEW

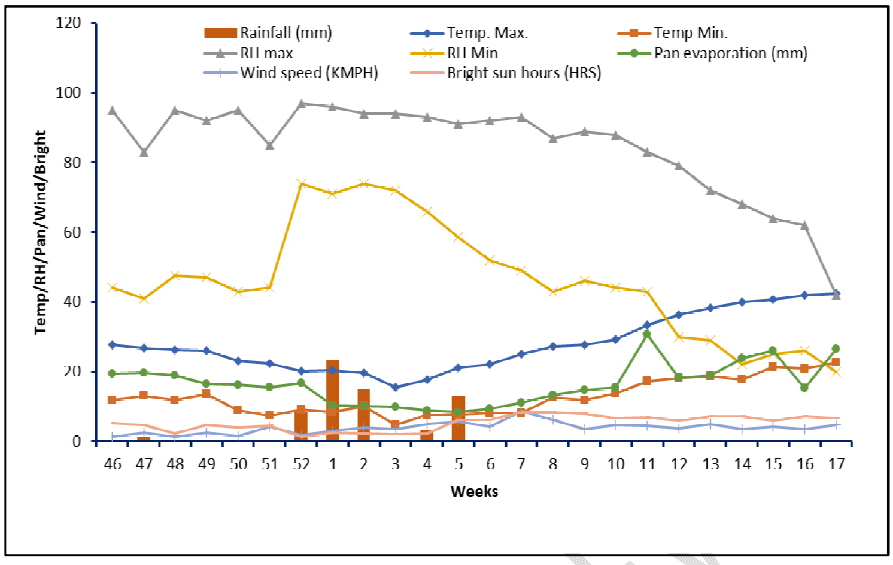

Figure .1 Details of weather data during crop season (2022-23)

Comment [a2]: Mention month also

RESULTS AND DISCUSSION

Growth Characteristics

The findings concerning growth characteristics (Table 1) such as plant height (cm), number of tillers (m^{-2}) as well as crop growth rate (g m^{-2} day^{-1}), revealed that timely sown wheat variety, DBW-187 recorded significantly more plant height (3.05 cm, 3.50%), tillers (10.04 m^{-2}, 2.34%), and crop growth rate (0.014 g m^{-2} day^{-1}, 6.19%) as compared to PBW-723, respectively. It might be due to better genomic characteristics and suitability in particular environmental conditions. Among plant growth promoters, mixture of plant micronutrients (Zn, Fe, B, Cu) @ 5% exhibited more plant height (4.39%), nNumber of tillers (1.66%) and crop growth rate (0.130 g m^{-2} day^{-1}) as compared to control treatment. The gibberellic acid and sea weed extracts showed better performance but next to micronutrients in terms of increasing plant height, number of tillers and crop growth rate as compared to control treatments. The superior performance of the micronutrient mixture likely augmented the metabolic processes of wheat plants, thereby enhancing their growth traits compared to other growth-promoting substances. The application of micronutrients such as iron (Fe), zinc (Zn), boron (B), and copper (Cu) led to enhancements in both the nutritional status and physical conditions of soil. Although the micronutrients are required in small quantities their supplementation during the crop growth help in better utilization of all other nutrients which in tern resulted in increased growth of wheat. Similar findings were also reported by Hamed *et al.*

Comment [a3]: Provide citation in support

UNDER PEER REVIEW

[10] and Alsudays *et al*. [11].

Yield ~~Attributing Characteristics~~attributes

The data regarding yield attributing characters (Table 2) revealed that DBW-187 variety recorded significantly more number of ears m^{-2} (3.6, 0.85%), length of ears (0.76, 7.04%), number of seeds ear^{-1} (2.96, 4.41%), seed weight ear^{-1} (0.21, 8.71%) and test weight (1.24, 3.14%) as compared to variety PBW-723, respectively. The better yield attributes in DBW-187 are~~is~~ due to better growth characteristics~~s~~ compared to other variety. In plant growth promoter's the mixture of micronutrients (Zn, Fe, B, Cu) @ 0.5% recorded significantly more numbers of ear (2.09%), length of ear (20.54%), n~~N~~o. of grain ear^{-1} (8.33%), seed weight ear^{-1} ~~–~~(46.96%) and test weight (7.78%). The g~~G~~ibberellic acid showed better performance but next to the micronutrient~~s~~ mixture in terms of increasing number of ears (1.94%), length of ear (19.21%), number of seed ear^{-1} (7.96%), seed weight ear^{-1} (45.73%) and test weight (7.10%) compared to control treatments. The combined use of organic and inorganic sources of nutrients could be attributed to the better synchronicity of nutrient availability to the wheat crop, which was evidenced by higher grain yield and dry matter accumulation. The growth promoter g~~G~~ibberellic Acid (GA3) stimulates plant height and promotes the emergence of a greater number of tillers and functional leaves, where increased photosynthesis occurs, ultimately leading to higher dry matter accumulation. Seaweeds, particularly red and brown algae, play a role in modulating phytochrome activity, delaying senescence, enhancing tolerance to biotic stress, reducing transpiration, and boosting stomatal conductance, all of which contribute to enhanced plant growth. Similar findings were also reported by Deepana *et al.* [12], Mishra *et al*. [13] and Navya *et al.* [14].

Comment [a4]: Provide latest citation

Yield

The comparison between wheat varieties DBW-187 and PBW-723 regarding grain yield and straw yield (Table 2) revealed noteworthy findings. DBW-187 exhibited a notable increase in grain yield (16.28%) and straw yield (11.73%) compared to PBW-723. This superior performance of DBW-187 in terms of these factors can be attributed to its enhanced growth characteristics and better yield-contributing traits. The micronutrient mixture (Zn, Fe, B, Cu) @ 0.5% exhibited an increment in grain yield (31.16%) and straw yield (17.32%) compared to control treatment. Next to micronutrient g~~G~~ibberellic acid also reported better performance in terms of increasing grain yield 4545.8 kg ha^{-1} (30.7%). Both h~~H~~umesol and a~~A~~mino b~~B~~ooster G were found at par with each other but significant

UNDER PEER REVIEW

treatment better thanthen control treatment. The Iincrease in grain yield of wheat could be attributeds to application of a mixture of micronutrients. Further, the addition of micronutrients also helps in better utilization of the major nutrients to produce a higher yield of crops. Yield can be consider being the final expression of physiological and metabolic activities of plants and is governed by various factors. Seaweed extracts are known to improve to the source-sink relationship translocation of photo assimilates and their by photosynthetic ability of the plants and thus play significant role in realization of high productivity levels and higher grain yields. Similar findings were also reported by Vivek *et al*. [15] and Jat *et al.* [16].

Comment [a5]: Provide citation in support

UNDER PEER REVIEW

UNDER PEER REVIEW

Treatments	Plant height (cm)			Number of tillers (m^{-2})			Crop growth rate (g m^{-2} day^{-1})		
	45 DAS	90 DAS	Maturity	45 DAS	90 DAS	Maturity	0 to 45 DAS	45 to 90 DAS	90 DAS to harvesting
Variety									
DBW-187	38.74	78.97	87.04	382.66	453.01	427.93	0.198	0.226	0.184
PBW-723	36.94	75.84	83.99	362.89	442.65	417.89	0.178	0.212	0.176
SED ±	0.53	0.61	0.42	0.502	3.211	0.75	0.002	0.003	0.002
CD at 5%	NS	2.825	1.947	2.326	NS	3.473	0.01	0.013	NS
Plant growth promoters									
Control	34.62	74.58	82.75	367.73	443.15	418.07	0.165	0.113	0.128
Nitrobenzene @3ml/L	37.92	77.68	85.78	373.07	448.22	423.62	0.190	0.23	0.186
Gibberellic acid @2ml/L	39.08	78.43	86.38	374.58	449.72	424.62	0.200	0.238	0.194
Sea weed extracts(solid) @25kg/ha	38.35	77.93	86	373.77	448.85	423.93	0.191	0.232	0.188
Sea weed extracts(liquid) @625ml/ha	38.92	78.23	86.17	374.1	449.23	424.22	0.194	0.236	0.191
Micronutrients(Zn, Fe, Cu, B) @0.5%	39.48	78.6	86.55	375.23	450.18	425.13	0.202	0.243	0.196
UPL Macarena (fermented nutrient extract	37.03	76.68	85.1	371.5	446.3	421.12	0.18	0.224	0.177

Comment [a6]: Add variety number like V1 and V2

Comment [a7]: Add growth promoters number like G1, G2 etc.

UNDER PEER REVIEW

15%) @625ml/ha				2					
Humesol (humic acid 18%, fulvic acid 15%)				372.7	447.7				
@1250ml/ha	37.75	77.43	85.65	7	8	423.2	0.186	0.229	0.182
Amino Booster G (30% amino acid				372.1	447.0				
solution)@5ml/L	37.43	77.1	85.28	7	5	422.32	0.183	0.226	0.18
SED ±	1.007	0.531	0.18	1.586	1.472	1.165	0.004	0.004	0.004
CD at 5%	2.06	1.088	0.367	3.245	3.011	2.383	0.008	0.008	0.009
Interaction(V×G)									
SED ±	1.424	0.752	0.254	2.243	2.081	1.647	0.006	0.005	0.006
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 1. Effect of organic and inorganic plant growth promoters on growth attributing characteristics of wheat varieties

UNDER PEER REVIEW

Table 2. Effect of organic and inorganic plant growth promoters on yield attributes and yield of wheat varieties

	Yield attributes					Yield	
Treatments	**No. of ears m^{-2}**	**Ear length (cm)**	**No. of seeds ear^{-1}**	**Seed weight ear^{-1} (g)**	**Test weight (g)**	**Grain yield (kg ha^{-1})**	**Straw yield (kg ha^{-1})**
Variety							
DBW-187	418.81	10.79	67.09	2.41	39.49	4601.8	6982.1

Comment [a8]: Follow the same as mentioned in table 1

PBW-723	415.21	10.03	64.13	2.2	38.25	3852.5	6204.3
SED ±	0.158	0.106	0.19	0.023	0.18	30.446	27.709
CD at 5%	0.734	0.491	0.882	0.105	0.834	141.038	128.36
Plant Growth Promoters							
Control	411.72	8.78	61.92	1.4	36.72	3147.18	5847.18
Nitrobenzene @3ml/L	417.42	10.52	65.95	2.4	38.98	4332.02	6648.57
Gibberellic acid @2ml/L	419.9	10.95	67.28	2.58	39.53	4545.8	6961.08
Sea weed extracts(solid) @25kg/ha	418.07	10.67	66.4	2.46	39.15	4405.5	6761.08
Sea weed extracts(liquid) @625ml/ha	419.05	10.8	66.83	2.52	39.33	4465.23	6883.3
Micronutrients(Zn, Fe, Cu, B) @0.5%	420.53	11.05	67.55	2.64	39.82	4572.17	7072.2
UPL Macarena (fermented nutrient extract 15%) @625ml/ha	414.77	10.22	64.23	2.16	38.6	4133.3	6248.6
Humesol (humic acid 18%, fulvic acid 15%) @1250ml/ha	416.2	10.43	65.47	2.33	38.88	4241.68	6506.92
Amino Booster G (30% amino acid solution)@5ml/L	415.43	10.28	64.87	2.26	38.8	4201.35	6409.67
SED ±	0.599	0.187	0.261	0.033	0.505	44.067	27.842
CD at 5%	1.225	0.383	0.534	0.067	1.033	90.169	56.971
Interaction(V×G)							
SED ±	0.847	0.264	0.369	0.046	0.714	62.32	39.375
CD at 5%	NS	NS	NS	0.12	NS	161.635	117.003

Comment [a9]: Follow the same as mentioned in table 1

UNDER PEER REVIEW

CONCLUSION

The result of the current investigation shows that the variety of wheat DBW-187 recorded better growth and grain yield (4601.8 kg ha^{-1}) under timely sown (5th ~~december~~December 2022) compared to other variety. Among plant growth promoters, the mixture of micronutrients (Zn, Fe, B, and Cu) recorded maximum growth attributes, grain yield (4572.17 kg ha^{-1}) compared to control treatment. These findings underscore the significance of both varietal selection and ~~judiciuous~~judicious use of plant growth promoters in enhancing wheat production.

Formatted: Superscript

Formatted: Superscript

Comment [a10]: Enhance the sentence

Also include the future line of research.

COMPLIANCE WITH ETHICAL STANDARDS

Ehical issues: None

References

Comment [a11]: Not as per the journal format. Refer to the guidelines and align as per the journal format.

(More focus on author, year, paper title, journal abbreviation, volume number, issue number and page number). The scientific name should be Italic.

Kindly check all the references which are cited above text.

Formatted: Font: Italic

1. **Kinga M, Idzi S, Roman K, Jolanta Roman K (2020).** Effect of foliar applied acetylsalicylic acid on wheat (*Triticum aestivum* L.) under field conditions. Agron 10:1–19.
2. **Anonymous, (2022).** World Agricultural Production 2022, USDA (United State Department of Agriculture).
3. **Jones, D. L., Cross, P., Withers, P. J. A., Deluca, T. H., Robinson, D. A., Quilliam, R. S., Harris, I. M., Chadwick, D. R. and Edwards- Jones, G. (2013).** Review: nutrient stripping the global disparity between food security and soil nutrient stocks. *J Appl Ecol* 50: 851 62.
4. **Singh, M.V. (2009).** Micronutrient nutritional problem in soils of India and improved for human and animal health. *Indian journal of fertilizer*, 5. 11-16, 19-26 & 56.
5. **Subba, R. A. and Srivastava, S. (1998).** Role of plant nutrients in increasing crop productivity *Fert News* 43. 65-75
6. **Desta, B. and Amare, G. (2021).** Paclobutrazol as a plant growth regulator. Chem Biol Technol Agric 8:1–15. https:// doi. org/ 10. 1186/s40538- 020- 00199-z
7. **Quamruzzaman MD, Nuruzzaman SM, ManikShabala S, Zhou M (2021).** Improving performance of salt-grown crops by exogenous application of plant growth regulators. *Biomolecules* 11(6):788. https:// doi. org/ 10. 3390/ biom1 10607 88.
8. **Attia H, Alamer K, Algethami B (2022).** Gibberellic acid interacts with salt stress on germination, growth and polyamine gene expression in fennel (*Foeniculum*

UNDER PEER REVIEW

vulgare Mill) seedlings. Physiol Mol Biol Plants 28:607–622. https:// doi. org/ 10. 1007/ s12298- 022- 01140-4

9. **Veselov DS, Kudoyarova GR, Kudryakova NV, Kusnetsov VV (2017).** Role of cytokinins in stress resistance of plants. Russ J Plant Physiol 64(1):15–27

10. **Hamed, E.N., (2021).** Effect of salicylic, humic and fulvic acids application on the growth, productivity and elements contents of two wheat varieties grown under salt stress. *Journal of Soil Sciences and Agricultural Engineering*, *12*(10), pp.657-671.

11. **Alsudays, I.M., Alshammary, F.H., Alabdallah, N.M., Alatawi, A., Alotaibi, M.M., Alwutayd, K.M., Alharbi, M.M., Alghanem, S.M., Alzuaibr, F.M., Gharib, H.S. and Awad-Allah, M.M., (2024).** Applications of humic and fulvic acid under saline soil conditions to improve growth and yield in barley. *BMC Plant Biology*, *24*(1), p.191.

12. **Deepana, P. Bama, K. S., Santhy, P. & Devi, T. S. (2021).** Effect of seaweed extract on rice (Oryza sativa var ADT53) productivity and soil fertility in Cauvery delta zone of Tamil Nadu, India. *Journal of Applied and Natural Science*, 13(3), 1111-1120.

13. **Mishra, B., Yadav, R. K., Singh, S. P., Singh, A. K. & Singh, A. K. (2021).** Effect of foliar application of plant growth regulators on growth and development, biochemical changes and yield of mung bean (*Vigna radiata* L). *Journal of Pharmacognosy and Phytochemistry*, 10(1), 2789-2794.

14. **Navya, P. P., Akhila, M. & Dawson, J. (2021).** Effect of plant growth regulators on growth and yield of *Zaid* Mung bean (*Vigna radiata* L. *Journal of Pharmacognosy and Phytochemistry*. 10(2), 1228. 1230.

15. **Vivek, C. M. (2020).** Effect of Foliar Application Iron Ferilizers on Nutrients Concentration of Wheat Grain. *European Journal of Molecular & Clinical Medicine*, 7(07).

16. **Jat, R. C., Sharma, Y., Jakhar, R. K. & Sharma, R. K. (2018).** Effect of phosphorus, zinc and iron on yield and quality of wheat in western Rajasthan, India. *Int. J. Curr. Microbial. App. Sci*, 7(3), 2055-2062.

UNDER PEER REVIEW