Influence of Nitrogen and Plant Growth Regulators on Yield and Economics of Wheat (*Triticum aestivum* L.)

ABSTRACT

A field experiment was conducted during *rabi* season, 2022 at crop research farm, Department of Agronomy at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj Uttar Pradesh India. The objective is to study Influence of nitrogen and plant growth regulators on yield and economics of wheat (*Triticum aestivum* L.). The research consists of three levels of Nitrogen (120, 140 and 160 kg/ha) and three plant growth regulators [CCC – 0.2%, Tebuconazole – 0.1% and CCC – 0.2% + Tebuconazole – 0.1%]. The experiment was laid out in randomized block design (RBD) with ten treatment combinations and replicated thrice. The soil in experimental field was sandy loam in texture, having alkaline reaction (pH 7.7) with very low organic carbon (0.44%), available higher level N (171.48 kg/ha), P (27.0 kg/ha) and higher level of K (291.2 kg/ha). Application of Nitrogen (160 kg/ha) along with CCC (Chlormequat chloride) - 0.2% and Tebuconazole - 0.1% showed significantly higher yield attributes *viz.* maximum number of effective tillers/m^2 (271), more spike length (15.10 cm), maximum number of grains/spike (60.05), higher test weight (39.75), and yield *viz.* Higher grain yield (4.66 t/ha) and Straw yield (6.98 t/ha). Economics of treatments *viz.* maximum Gross returns (140928.42 INR/ha), maximum Net returns (99715.52 INR/ha) and Benefit - cost ratio (2.42) was recorded in treatment - T_9 [N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)]

Keywords: Nitrogen, Plant Growth Regulator, *Chlormequat Chloride, Tebuconazole*, Yield attributes, Yield and Economics.

INTRODUCTION

"Wheat (*Triticum aestivum* L.) a staple crop of the world contributing as a food source for more than 40 % of the world's population is the principle cereal crop" (**Acevedo *et al.,* 2018**). "It is rich in carbohydrate, protein, fat and minerals (zinc, iron) and also contains good source of vitamins such as thiamine and vitamin-B" (**Kumar *et al.,* 2011).** "Wheat is also a good source of essential dietary substances like carotenoids, flavonoids and phenolic compounds" (**Ma *et al.,* 2015**).

"Wheat is basically a temperate region crop but can also be grown under different subtropical and tropical conditions successfully. Wheat is grown mainly in two seasons in the world *viz*. Winter and spring.

The massive importance of wheat can be understood with the figures of grown area of 220.30 million hectares with annual production of 788.26 million metric tons and productivity of 3.58 t/ha during 2022-23 worldwide" **(USDA 2020).** "In India huge portion of total cultivation devoted under this crop, nearly 31.45 million hectares area with annual production of 107.59 million tones carrying average productivity 34.21 q/ha in year 2019-20" **(Pocket book of Agricultural Statistics 2020).**

"Among the essential nutrients, nitrogen plays important role in augmenting the agricultural production and its deficiency limits crop production" (**Aulakh and Malhi 2005, Kumar *et al.,* 2017**). "The most important role of Nitrogen in the plant is its presence in the structure of protein, the most important building substances from which the living material or protoplasm of every cell is made" (**Blumenthal *et al.,* 2008**). Nitrogen occupies a conspicuous place in plant metabolism. All vital processes in plant are associated with protein, of which nitrogen is an essential constituent. Consequently, to get more crop production, nitrogen application is essential in the form of chemical fertilizer.

"Growth retardants are chemical substances that have the potential to alter structural or vital processes inside the plant by modifying hormone balance to increase yield, improve quality or facilitate harvesting through checking lodging especially in cereals. Lodging preventers (plant height retardants) are generally antagonistic to gibberellin. The nature and extent of lodging are closely related to height of the stem, which can be modified by application of growth inhibitors" **(Peng *et al.,* 2014)**.

Chlormequat has been called the "most important inhibitor of gibberellin biosynthesis." As such, it inhibits cell elongation, resulting in thicker stalks, which are sturdier, facilitating harvesting of cereal crops. Application of growth inhibitors, like CCC (Chlormequat Chloride), or tebuconazole was reported to be useful in decreasing plant height and subsequently reducing lodging. The fungicide, tebuconazole, not only controls disease but also more effective than some proprietary plant growth regulators in reducing canopy growth. Folicur contains Tebuconazole a systemic triazole fungicide. Keeping above facts in view an experiment was laid out on "Effect of nitrogen and plant growth regulators on yield and economics of wheat (*Triticum aestivum* L.)".

MATERIALS AND METHODS

"A field experiment was carried out during *rabi* season of 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj Uttar Pradesh. The crop research farm is situated at 25^0 39" 42" N latitude, 81^0 67" 56" E longitude and at an altitude of 98 m above mean sea level. The experiment was laid out in randomized block design consisting ten treatment combinations with three replications with different treatments assigned randomly in each replication. The soil in experimental field was sandy loam texture, having alkaline reaction (pH 7.7) with very low organic carbon (0.44%), available higher N (171.48 kg/ha), P (27.0 kg/ha) and higher level of K (291.2 kg/ha)". (Ma et al., 2015). The treatment combinations were T_1 - Nitrogen 120 kg/ha + CCC (Chlormequat chloride) - 0.2% , T_2 - Nitrogen 140 kg/ha + CCC (Chlormequat chloride) - 0.2%, T_3 - Nitrogen 160 kg/ha + CCC (Chlormequat chloride) - 0.2%, T_4 - Nitrogen 120 kg/ha + Tebuconazole (0.1%), T_5 - Nitrogen 140 kg/ha + Tebuconazole (0.1%), T_6 - Nitrogen 160 kg/ha + Tebuconazole (0.1%), T_7 - Nitrogen 120 kg/ha + CCC (0.2%) + Tebuconazole (0.1%), T_8 - Nitrogen 140 kg/ha + CCC (0.2%) + Tebuconazole (0.1%), T_9 - Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) and T_{10} - Control (150-60-40 NPK kg/ha). The crop was sown on 14th December 2022 with seed rate of 100 kg/ha at a spacing of 22.5 cm × 10 cm. The recommended dose of phosphorus (60 kg/ha) and potassium (40 kg/ha) was applied in the form of SSP and MOP as basal at the time of sowing and Nitrogen was applied through Urea as per the treatments in split doses during crop period. The plant growth regulators were applied twice with 1st spray [(CCC (0.2%), Tebuconazole (0.1%) and CCC (0.2%) + Tebuconazole (0.1%)] at 40 days after sowing and 2nd spray at 55 days after sowing. Weeds were kept under control by manual weeding whenever necessary. Thinning was done at 21 days after sowing to maintain proper plant spacing. The observations were recorded on yield and yield parameters *viz.* number of effective tillers/m^2, spike length (cm), Number of Grains/spike, Test weight (g), Grain yield (t/ha), Straw yield (t/ha) and were subjected to statistical analysis by "Analysis of Variance Technique". Gross Returns (INR/ha), Net Returns (INR/ha) and Benefit - Cost Ratio (B:C) were analysed by mathematical method.

Number of effective tillers per m^2: Total number of grains bearing tillers from two observational units of one metre row length were counted and mean was recorded as number of effective tillers per metre row length. The mean so calculated was multiplied by factor 4 to get number of effective tillers/m^2.

Spike length (cm): Five representative spikes were harvested from marked rows. The spike length (cm) was measured from the base of the peduncle (lower spikelet) to the tip of the top spikelet.

Number of grains per spike: From the spikes selected for measuring spike length, the grains were separated from spikelet and the number of grains were counted and the grains per spike were worked out.

Test weight (g): A random sample of 1000 seeds was taken from the harvested bulk and was weighed.

Grain yield (t/ha): Grain yield from the harvest area (1.0 m^2) was dried in sun, cleaned and weighed separately from each plot for calculating the seed yield in t/ha.

Straw yield (t/ha): Straw yield was calculated by subtracting grain yield from biological yield for each of net plot area and expressed in (t/ha).

Statistical analysis: the data recorded during the course of investigation was subjected to statistical analysis by "Analysis of variance technique". The significant and non-significant treatment effects were judged with the help of 'F' (variance ratio) table. The significant differences between the means were tested against the critical difference at 5% probability level. Statistical analysis was performed for randomized block design (**Gomez *et al.,* 1983**). The data was generated for one season and analysed statistically.

RESULTS AND DISSCUSION

Yield Parameters

Number of effective tillers/m^2

The data revealed that treatment with application of Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) significantly recorded maximum number of tillers/m^2 (271) which was superior over all the treatments. However, the treatment Nitrogen 160 kg/ha + CCC (Chlormequat chloride) - 0.2% (257) which were found to be statistically at par with Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). Similar findings were reported by **Rodrigues *et al.,* (2003). Shahi (2016)** has also reported increase in number of tillers/m^2 with the application of higher dose of fertilizers.

"Significantly higher effective tiller density in high nutrient levels might be due to the optimal supply of nutrients, resulting in higher interception of photosynthetically active radiations and dry matter accumulation. Better nutrition resulted in better development of plants and more tillering accounting to more effective tillers produced in treatments with higher levels of nutrients. Other scientists have also reported higher tiller density with higher nutrient levels" (**Mauriya *et al.,* 2013; Mohanty *et al.,* 2015**)

Spike length (cm)

The data revealed that treatment with application of Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) significantly recorded highest spike length (15.10 cm). whereas, the treatments Nitrogen 160 kg/ha + CCC (Chlormequat chloride) - 0.2% (13.29), Nitrogen 160 kg/ha + Tebuconazole - 0.1% (13.83) and Nitrogen 140 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) (13.00 cm) were found to be statistically at par with Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). These results are in conformity with those of **Ali *et al.,*** and **Asif *et al.,* (2009)**

However more spike length was observed at 160 kg/ha nitrogen level. These results are in agreement with those of **Hussain *et al.,* (2001)** and **Ahmad *et al.,* (2000).** They concluded that spike length of wheat increased significantly with increasing nitrogen levels.

Number of grains/spike

The data revealed that treatment with application of Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) significantly recorded more number of grains/spike (60.05). However, the treatment Nitrogen 160 kg/ha + Tebuconazole - 0.1% (54.66) was found to be statistically at par with Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). ***Ali et al.,* (2011)** observed that number of grains/spike, 1000 grain weight and grain yield were significantly increased by increasing the nitrogen level over control. Among nitrogen levels, highest grain yield was obtained by an application of 180 kg N/ha.

Test weight (g)

The data revealed that treatment with application of Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) significantly recorded higher test weight (39.75 g). whereas, the treatments with Nitrogen 160 kg/ha + CCC (Chlormequat chloride) - 0.2% (39.21) and Nitrogen 160 kg/ha + Tebuconazole - 0.1% (39.01 g) were found to be statistically at par with Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). The test weight was increased by application of growth regulator. This result may be discussed in the light of fact that due to reduction in plant height there was less competition between the plants for light absorption which help in better photosynthesis and more accumulation of photosynthates in grains **(Dastan *et al.,* 2011).**

Grain Yield (t/ha)

The data revealed that treatment with application of Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) significantly recorded highest Grain yield (4.66 t/ha) which was superior over all the treatments. However, the treatment with Nitrogen 140 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) (4.28 t/ha) was found to be statistically at par with Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). The higher grain yield could be due to more dry matter accumulation in grain and number of grains per spikes because of application of plant growth regulator. The finding is supported by **Rahman *et al.,* (2011). Bahrami *et al.,* (2014)** also found that height reduction at tillering led to higher tiller survival and enhanced fertile tillers, which resulted in higher yield.

Straw yield (t/ha)

The data revealed that treatment with application of Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) significantly recorded highest straw yield (6.98 t/ha). whereas, the treatment with Nitrogen 160 kg/ha + Tebuconazole - 0.1% (6.71 t/ha) was found to be statistically at par with Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). **Khalil *et al*., (2011)** reported that "each increment of N increased biological yield and maximum yield (100.9 q/ha) recorded at 160 kg/ha nitrogen as compared to 80 kg/ha nitrogen. The growth regulator application also had a significant effect on the biological yield".

Table: 1 Influence of Nitrogen and Plant Growth Regulators on Yield Attributes and Yield of Wheat.

S. No.	Treatment combination	Number of effective tillers/m^2	Spike length (cm)	Number of grains/spike	Test weight (g)	Grain Yield (t/ha)	Straw Yield (t/ha)
1	N_1- 120 kg/ha + CCC (Chlormequat chloride) - 0.2%	219	10.60	43.89	36.07	3.78	5.82
2	N_2-140 kg/ha + CCC (Chlormequat chloride) - 0.2%	256	12.43	49.50	35.50	4.04	6.02
3	N_3 -160 kg/ha + CCC (Chlormequat chloride) - 0.2%	257	13.29	52.33	39.21	4.15	6.14
4	N_1- 120 kg/ha + Tebuconazole - 0.1%	243	9.97	49.00	36.20	3.63	5.74
5	N_2-140 kg/ha + Tebuconazole - 0.1%	251	12.00	52.00	37.28	4.14	6.27
6	N_3 -160 kg/ha + Tebuconazole - 0.1%	255	13.83	54.66	39.01	4.17	6.71
7	N_1- 120 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)	239	11.10	47.84	36.47	3.98	5.89
8	N_2-140 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)	242	13.00	50.00	37.38	4.28	6.40
9	N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)	271	15.10	60.05	39.75	4.66	6.98
10	Control (150-60-40 NPK kg/ha)	234	9.47	43.35	33.77	3.68	5.63
	F-test	S	S	S	S	S	S
	SEm(±)	7.62	0.56	1.68	1.12	0.13	0.25
	CD (p=0.05)	22.63	1.68	5.0	3.34	0.38	0.73

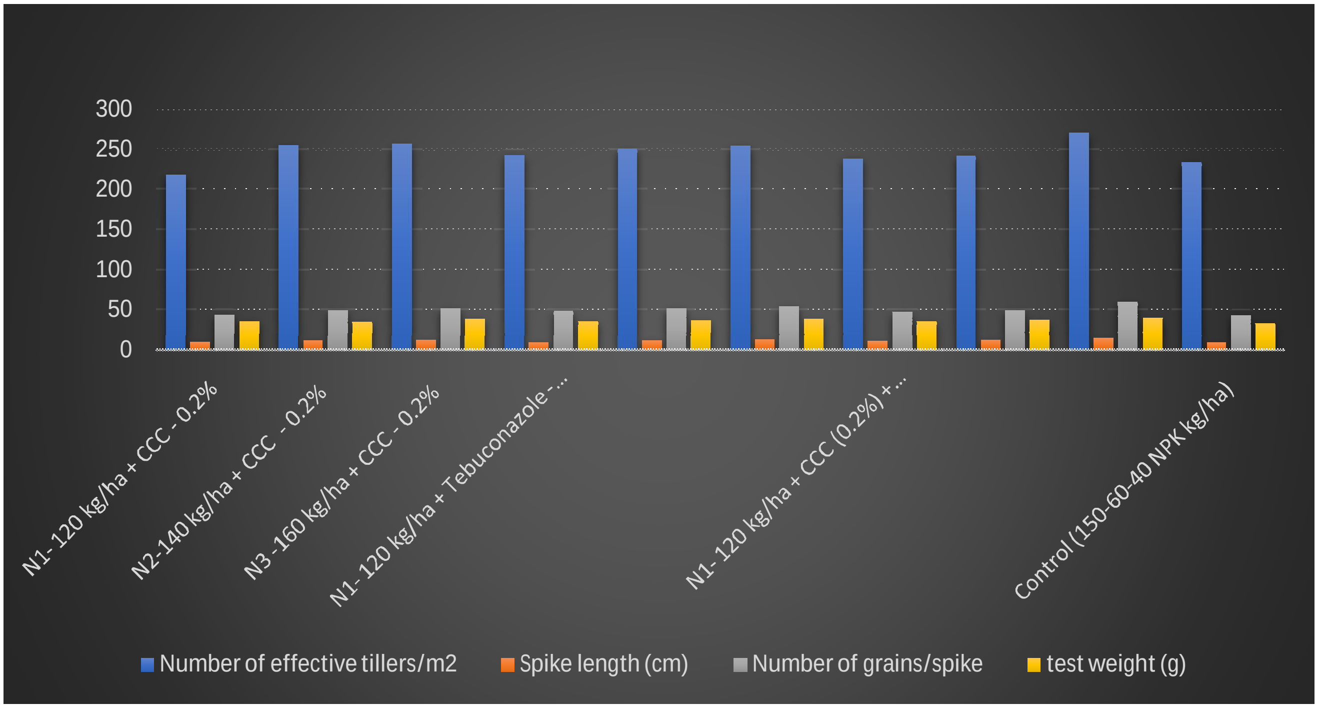

Fig 1: Interaction effect of nitrogen and plant growth regulators on yield attributes of wheat

ECONOMICS

Cost of cultivation (INR/ha)

Highest cost of cultivation was recorded with the treatment Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) (41212.90 INR/ha) followed by Nitrogen -140 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) (40973.87 INR/ha). Whereas minimum cost of cultivation (36893.44 INR/ha) was recorded with Control (150-60-40 NPK kg/ha).

Gross returns (INR/ha)

Maximum Gross returns were recorded with the treatment of Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) (Rs. 140928.42 INR/ha) followed by Nitrogen - 140 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) (129312.92 INR/ha). whereas minimum gross return was recorded with treatment Nitrogen 120 kg/ha + Tebuconazole - 0.1% (Rs. 111628.17 INR/ha).

Net returns (INR/ha)

Highest Net returns were recorded with the treatment of Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) (Rs. 99715.52 INR/ha) followed by Nitrogen -160 kg/ha + Tebuconazole - 0.1% (89250.60 INR/ha). Whereas minimum Net returns were recorded with treatment Nitrogen 120 kg/ha + Tebuconazole - 0.1% (Rs. 72393.44 INR/ha).

Benefit cost ratio (INR/ha)

Maximum Benefit cost ratio was recorded with the application of Nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) (2.42) over rest of the treatments followed by Nitrogen 160 kg/ha + Tebuconazole - 0.1% (2.25). Whereas lower Benefit cost ratio was recorded with treatment Nitrogen 120 kg/ha + Tebuconazole - 0.1% (1.85). **Buj (2018**) reported that application of chlormequat chloride 0.2% + tebuconazole 0.1% was found superior over control with respect to net return as well as B:C ratio (1.95) but found statistically at par with tebuconazole 0.1% alone.

Table: 2 Influence of Nitrogen and Plant Growth Regulators on Economics of Wheat.

Sr. No.	Treatment combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C
1	N_1- 120 kg/ha + CCC (Chlormequat chloride) - 0.2%	38734.73	115319.67	76584.94	1.98
2	N_2-140 kg/ha + CCC (Chlormequat chloride) - 0.2%	38973.87	121871.92	82898.05	2.13
3	N_3 -160 kg/ha + CCC (Chlormequat chloride) - 0.2%	39212.9	125017.17	85804.27	2.19
4	N_1- 120 kg/ha + Tebuconazole - 0.1%	39234.73	111628.17	72393.44	1.85
5	N_2-140 kg/ha + Tebuconazole - 0.1%	39473.87	125640.75	86166.88	2.18
6	N_3 -160 kg/ha + Tebuconazole - 0.1%	39712.90	128963.50	89250.60	2.25
7	N_1- 120 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)	40734.73	119891.58	79156.85	1.94
8	N_2-140 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)	40973.87	129312.92	88339.05	2.16
9	N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)	41212.90	140928.42	99715.52	2.42
10	Control (150-60-40) NPK kg/ha	36893.44	112059.00	75165.56	2.04

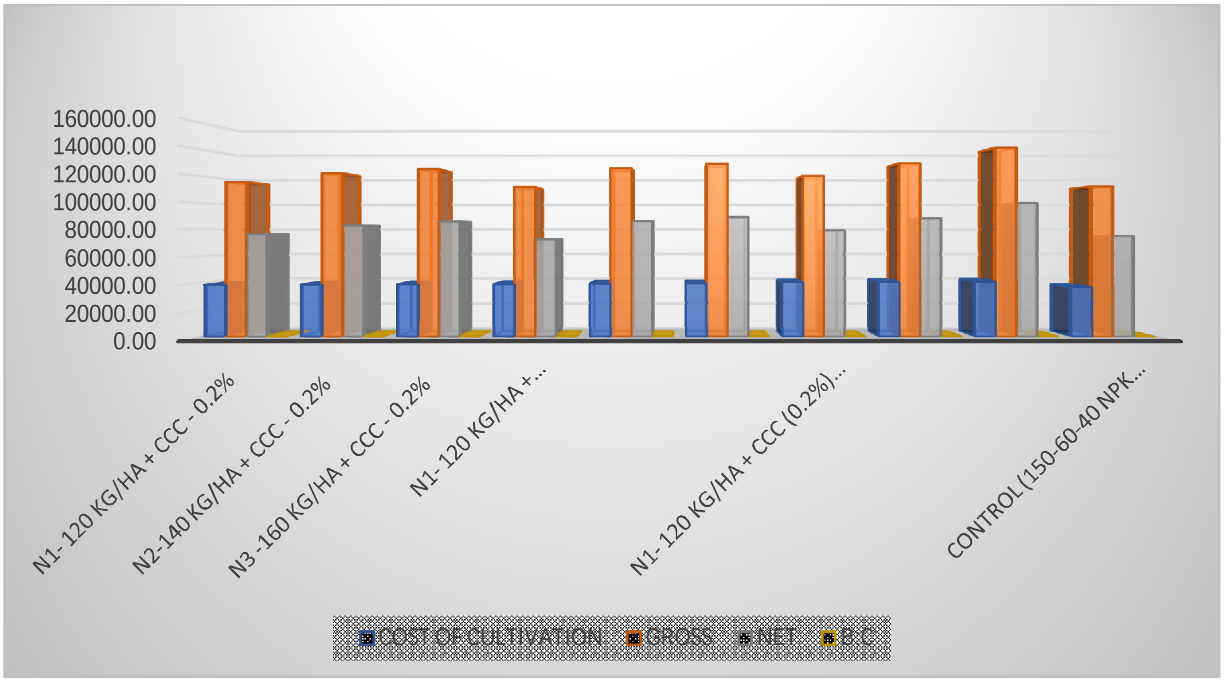

Fig 2: Interaction effect of nitrogen and plant growth regulators on economics of wheat

CONCLUSION

In the light of the above study, it is concluded that application of Nitrogen at 160 kg/ha along with application of Chlormequat chloride (0.2%) and Tebuconazole (0.1%) in Treatment 9 was found more productive and observed maximum Grain yield (4.66 t/ha) and benefit cost ratio (2.42) in wheat crop.

ACKNOWLEDGEMENT

I express my gratitude to my Advisor **Dr. Rajesh Singh** for constant support, guidance and valuable suggestions for improving the quality of this research work and to all the faculty members of Department of Agronomy, SHUATS, Prayagraj, Uttar Pradesh for providing all necessary facilities, their cooperation, encouragement and support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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