Original Research Article

"Response of Nitrogen and Plant Growth Regulators on Growth and Yield 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 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). To evaluate the response of nitrogen and different plant growth regulators on growth and yield of wheat (*Triticum aestivum*) the experiment was laid out in Randomized Block Design (RBD) with ten treatments each replicated thrice. The treatment consists three levels of nitrogen (120 kg/ha, 140 kg/ha and 160 kg/ha), in combination with two sprays of Plant growth regulators *viz*. [Chlormequat chloride (0.2%), Tebuconazole (0.1%) and chlormequat chloride (0.2%) + tebuconazole (0.1%)] applied at 40 DAS followed at 55 DAS whose effect was observed on wheat. The results revealed that, higher plant height (98.70 cm), was recorded with treatment nitrogen 160 kg/ha along with Tebuconazole (0.1%). However, maximum number of tillers/running row meter (78.33), maximum dry weight (23.01 g/plant), more number of effective tillers/m^2 (271), highest spike length (15.10 cm), maximum number of grains/spike (60.05), higher test weight (39.75 g), maximum grain yield (4.66 t/ha),) and straw yield (6.98 t/ha) were recorded with treatment nitrogen-160 kg/ha along with CCC (0.2%) and Tebuconazole (0.1 %) in wheat. Application of both zinc and boron improved the growth and yield of wheat significantly.

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

INTRODUCTION

Worldwide, wheat (*Triticum aestivum* L.) being a staple food for large population contributing about 20% of humans' daily dietary calorie and protein intake **Shiferaw *et al.*, (2013**). Wheat is the second most important food grain of India with an area of 30.5 million hectare, production of 98.4 Million tonns, and an average productivity of 3216 kg/ha (Anonymous 2016). Rajasthan is one of the major wheat growing state in India with an area of 3.11 Million hectare (10.3% area of country), 9.90 Million tonns of production (10.6% production share at the national level), and productivity of 3175 kg/ha (Anonymous 2016). Lodging, usually characterized by permanent displacement of stems from an upright position due to internal and external factors, is an important constraint limiting wheat yields and quality in both developed and developing countries **Berry *et al.*, (2003**).

Nitrogen is considered as most important fertilizer element determining the productivity of wheat. Higher wheat yields realized by applying greater doses of N fertilizers due to improved lodging resistance, resulting from short-stiff straw, is moderately expressed at moderate nitrogen levels. However, even spring wheat cultivars carrying Norin 10 dwarfing genes have been reported to lodge **Narang *et al.*, (1994).** Application of N at higher rates decreases breaking strength of the 2nd internode, decreases stem strength leading to increased lodging and decreased wheat yields and its components.

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 **Zhang *et al.*, (2017**). Lodging preventers (plant height retardants) are generally antagonistic to gibberellin and act by altering their metabolism **Peake *et al.*, (2014**) and for aforesaid reason they are frequently called anti-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**). Application of growth inhibitors, like ethephon (2-chloro ethyl phosphonic acid) or CCC (Chlormequat Chloride), was reported to be useful in decreasing plant height and subsequently reducing lodging **Niu *et al.*, (2012), Pitre *et al.*, (2007**). Therefore, the objective of present study was to determine the effects of different fertility practices and lodging preventers on growth behaviour, productivity and farm profitability of wheat under semi-arid conditions.

MATERIALS AND METHODS

A field experiment was conducted during Rabi season, 2022 at Central Crop Research Farm, Department of Agronomy, SHUATS Prayagraj, Uttar Pradesh. The soil of 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). The experiment was conducted in randomized block design consist three levels of nitrogen (120 kg/ha, 140 kg/ha and 160 kg/ha), in combination with two sprays of Plant growth regulators *viz.* [Chlormequat chloride (0.2%), Tebuconazole (0.1%) and chlormequat chloride (0.2%) + tebuconazole (0.1%)] and control. There were ten treatments each replicated thrice. The biometric observations were recorded at various stages of crop growth on different characteristics *viz.*, plant height(cm), number of tillers/running row meter, plant dry weight (g)and crop growth rate on five plants randomly selected from each net plot.

Post harvest studies include 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 harvest index (%) were also calculated.

Plant height (cm): The average height of plants was recorded at an interval of 25 DAS. The height of plant was measured from the base of the plant up to the tip. Height of the plants was recorded at 25,50,75,100 days after sowing and five plants were randomly selected from each plot which was tagged for observations.

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): Seed yield from the harvest area (1.0 m2) were 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).

List 1 : TREATMENT COMBINATIONS

Treatment number	**Treatment Details**
T_1	1. N_1- 120 kg/ha + CCC (Chlormequat chloride) - 0.2%
T_2	2. N_2-140 kg/ha + CCC (Chlormequat chloride) - 0.2%
T_3	3. N_3 -160 kg/ha + CCC (Chlormequat chloride) - 0.2%
T_4	4. N_1- 120 kg/ha + Tebuconazole - 0.1%
T_5	5. N_2-140 kg/ha + Tebuconazole - 0.1%
T_6	6. N_3 -160 kg/ha + Tebuconazole - 0.1%
T_7	7. N_1- 120 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)
T_8	8. N_2-140 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)
T_9	9. N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)
T_{10}	10. Control (150-60-40 NPK kg/ha)

RESULTS AND DISCUSSION

Growth Attributes

Plant height (cm)

The fertility practices had significant effect on plant height of wheat at all the growth stages. At 100 DAS, significantly higher plant height (98.70 cm) was recorded in treatment 6 with application of N_3 -160 kg/ha + Tebuconazole - 0.1% as compared with other treatments. However, treatment 3 with application of N_3 -160 kg/ha + CCC (Chlormequat chloride) - 0.2% and treatment with application of nitrogen 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) were statistically at par with treatment 6 [N_3 -160 kg/ha + Tebuconazole - 0.1%]. This is due to retardant properties of plant growth regulators results a significant reduction in plant height during the entire growing season even with the higher dose of nitrogen. Similar findings were recorded by **Rajala *et al.*, (2002); Kesarwani *et al.*, (2018)**.

Application of double PGRs enabled the plant for reduction of plant height over single PGRs. This might be due to Chloremequat chloride inhibits gibberellin biosynthesis via blocking ent-kaurene synthesis in the metabolic pathway of gibberellin production, resulting in reduced amounts of active gibberellins and consequent reduction in stem elongation **Anosheh *et al.*, (2016)**

Number of tillers/running row metre

At 100 DAS, the data revealed that a significantly maximum number of tillers/running row meter (78.33) was recorded in treatment 9 with application of N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) which was superior over all other treatments. Treatment 6 with application of N_3 -160 kg/ha + Tebuconazole - 0.1% (72) were statistically at par with treatment 9 [N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)]. Similar findings were reported by **Rodrigues *et al.*, (2003).**

The increase in tiller production was probably because of greater supply of nitrogen to be used for cell multiplication and enlargement and also for the formation nucleic acid and other vitally important compounds in the cell sap. These results are in agreement with the previous finding by **Zhang (1997)** and **Gouping *et al.*, (2002).**

Plant dry weight (g)

At 100 DAS, significantly maximum plant dry weight (23.01 g) was recorded in treatment 9 with application of N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). Whereas, treatment

6 [N_3 -160 kg/ha + Tebuconazole - 0.1% (22.02 g)] and treatment 3 [N_3 -160 kg/ha + CCC (Chlormequat chloride) - 0.2% (21.68 g)] were statistically at par with treatment 9 [N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)]. Since, the major nutrient (nitrogen) are known as important constituents for cell division and cell elongation and their optimum availability with integrated use of organic and inorganic nutrient sources led to higher plant growth. Higher availability of these nutrients might improve photosynthetic area of plants that cumulatively contribute to higher dry matter accumulation. The results of study are in close agreement with the results of **Fliessbach *et al.*, (2007), Joergensen *et al.*, (2010), Leifeld *et al.*, (2009).**

The highest dry weight was recorded in the maturity stage due to the mass accumulation of the crop and also the dry weight increased with application of plant growth regulator, might be due to the better growth of healthy seedlings. Similar findings were also reported by **Kumar and Yadav (2005)**.

Crop Growth Rate (g/m^2/day)

During 50-75 DAS significantly maximum crop growth rate (0.0059 g/m^2/day) was recorded in treatment 9 with application of N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). However, crop growth rate (0.0054 g/m^2/day) in treatment 6 with application of N_3 -160 kg/ha + Tebuconazole (0.1%) was statistically at par treatment 9 [N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)].

Table 1: Response of Nitrogen and Plant Growth Regulators on Growth parameters of Wheat.

Sr. No.	Treatment combinations	Plant height at 100 DAS	Number of tillers/running row meter 100 DAS	Dry weight (g) at 100 DAS	CGR(g/m^2/day) 50-75 DAS
1	N_1- 120 kg/ha +CCC (Chlormequat chloride) - 0.2%	83.07	61.00	18.24	0.0038
2	N_2-140 kg/ha + CCC (Chlormequat chloride) - 0.2%	90.60	69.00	18.76	0.0046
3	N_3 -160 kg/ha + CCC (Chlormequat chloride) - 0.2%	97.03	67.67	21.68	0.0037
4	N_1- 120 kg/ha + Tebuconazole - 0.1%	85.21	62.67	19.19	0.0042
5	N_2-140 kg/ha + Tebuconazole - 0.1%	91.72	66.67	20.77	0.0033
6	N_3 -160 kg/ha + Tebuconazole - 0.1%	98.70	72.00	22.02	0.0054
7	N_1- 120 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)	81.83	65.00	19.22	0.0042
8	N_2-140 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)	88.68	70.00	21.14	0.0051
9	N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%)	95.17	78.33	23.01	0.0059
10	Control (150-60-40) NPK Kg/ha	83.79	62.00	18.56	0.0041
	F-test	S	S	S	S
	SEm(±)	2.86	2.19	0.74	0.0003
	CD (p=0.05)	8.50	6.51	2.20	0.0009

POST HARVEST OBSERVATION

Number of effective tillers/m^2

Number of effective tillers/m^2 showed significant difference among all treatments. Whereas, maximum number of effective tillers/m^2 (271) was observed in treatment 9 with application of N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). However, number of effective tillers/m^2 (257) of treatment 3 with application of N_3 -160 kg/ha CCC (Chlormequat chloride) - 0.2%, was found to be statistically at par with treatment 9.

Cycocel which is most widely used in wheat stimulates tillering, redistributes biomass with increased root growth, and reduces plant height and increase stiffness of straw that reduces the risk of lodging. The success of cycocel on wheat crop has been reported at commercial scale in many countries, especially under assured irrigation facilities and under high fertility **Kaur *et al.*, (2015).**

Spike Length (cm)

Spike length showed significant difference among all treatments. Whereas, highest spike length (15.10 cm) was observed in treatment 9 with application of N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). Whereas, spike length (13.29 cm) of treatment 3 with application of N_3 -160 kg/ha CCC (Chlormequat chloride) - 0.2%, spike length (13.83 cm) of treatment 6 with application of N_3 -160 kg/ha + Tebuconazole - 0.1% and spike length (13.00 cm) of treatment 8 with application of N_2-140 kg/ha + CCC (0.2%) + Tebuconazole (0. %1) was found to be statistically at par with highest. **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

Significantly maximum number of grains/spike (60.05) was observed in treatment 9 with application of N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). Followed by treatment 6 (54.66) grains/spike with application of N_3 -160 kg/ha + 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 nitrogen 180 kg/ha.

Test Weight (g)

The growth regulators led significant effect on test weight and the maximum values were recorded with the combined application of CCC + Tebuconazole highest test weight (39.75 g) was recorded in treatment 9 with application of N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). Whereas, test weight (39.21 g) in treatment 3 with application of N_3 -160 kg/ha + CCC (Chlormequat chloride) - 0.2% and test weight (39.01 g) of treatment 6 with application N_3 -160 kg/ha + Tebuconazole - 0.1% was found to be statistically at par with treatment 9. Similar results on wheat with the use of plant growth retardants were also reported by **Guoping *et al.*, (2001)** and **Rajala *et al.*, (2002)**

Grain Yield (t/ha)

Significantly higher grain yield (4.66 t/ha) of wheat was found in treatment 9 with application of N_3 -160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%) which was superior over all other treatments, followed by treatment 8 (4.28 t/ha) with application of N_2 - 140 kg/ha + CCC (0.2%) + Tebuconazole (0.1%). However, the minimum grain yield (3.63 t/ha) was observed in treatment 4. This might be due to increase the fertility levels which results more easily nutrients availability to the crop that results improved cell activities, enhanced cell multiplication and enlargement and luxuriant growth and yield attributes of the crops probably due to more absorption and utilization of available nutrients leading to overall improvement of crop growth reflected to source-sink relationship, which in turn enhanced the yield attributes that ultimately more yield **Paul *et al.*, (2016).**

Straw Yield (t/ha)

Growth regulators were influenced significant effect on straw yield, significantly maximum straw yield (6.98 t/ha) was recorded in treatment 9 with application of N_3 - 160 kg/ha + CCC (0.2%) + Tebuconazole (0.1%), followed by treatment 6 (6.71 t/ha) with application of N_3 - 160 kg/ha + Tebuconazole – (0.1%) were statistically at par with highest. These results are in close agreement with the results of earlier researchers **Tripathi *et al.*, (2003).**

Table 2: Response of Nitrogen and Plant Growth Regulators on yield and yield attributes of Wheat.

Sr.No.	Treatment combinations	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

CONCLUSION

On the basis of summarized results, it is concluded that for higher yield and income use of higher dose of nitrogen, 160 kg/ha with Plant Growth Regulators *viz.*, Chloremequat chloride - 0.2% along with Tebuconazole - 0.1% sprayed at 40 and 55 days after sowing is most appropriate for wheat cultivation.

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