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Response of Various Nitrogen Levels and Plant Growth Regulator on Production and Productivity of Wheat Crop (*Triticum aestivum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Author SC wrote the study, conducted the field work, collected the data and employed laboratory methodologies. employed laboratory methodologies. Author MSA completed the laboratory work and wrote the literature. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To study response of various nitrogen levels and plant growth regulator on production and productivity of wheat crop (*Triticum aestivum* L.)
Study Design: The field experiment was conducted in randomized block design (RBD).
Place and Duration of Study: A field experiment was carried out in the Agriculture Farm, School of Agriculture, Abhilashi University Chail chowk Mandi (H.P.) during *Rabi* Season 2022-2023.

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Methodology: Seven treatments namely T_1- Control (No Nitrogen and no growth regulator spray), T_2- 50% RDN (N_{60}, P_{60}, K_{40}), T_3- 75% RDN (N_{90}, P_{60}, K_{40}), T_4- 100% RDN (N_{120}, P_{60}, K_{40}), T_5- 125% RDN (N_{150}, P_{60}, K_{40}), T_6- 125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%), T_7- 150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%).
Results: The scrutiny of data clearly reveals that the application of 150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%) (T_7) gave significantly the highest value of growth parameter, yield attributes and yields, which is at par with T_6 [125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%)]. But the highest plant height was recorded under treatment (T_5) which is 125 % RDN (N_{150}, P_{60}, K_{40}) because under treatment T_7 & T_6 application of CCC causes the shortening of plant height. Nutrients were added according to treatment doses.
Conclusion: On the basis of one season study among various treatments, treatment T_7 -150% RDN (N_{180}, P_{60}, k_{40}) with growth regulator is best for enhancing the yield and productivity of wheat crop.

Keywords: Nitrogen; chlormequat chloride; wheat; RDN; PGR.

1. INTRODUCTION

“Wheat (*Triticum aestivum* L.) originated in Southwest Asia and belongs to the family Poaceae. Wheat is the major Rabi crop in India and is sensitive to various biotic and abiotic stresses like weather and inter-seasonal climatic variability (in terms of changes in temperature, rainfall, sunshine hours, etc), soil condition, and agricultural inputs like irrigation, fertilizer, and pesticides. Millions of people depend on it as a staple diet. After rice, wheat is a significant food crop in India. It is one of the main grains consumed in the nation and a staple diet in North India, where chapatti is preferred of all the crops farmed for grain worldwide, wheat is the most important. For half of the world’s population, it is one of the most important food crops and contributes 30% of the world’s total grain demand. It gives around 20% of the aggregate food calories for mankind” [1]. “The protein found in wheat is in form as gluten and is therefore good for yeast raised breads, which require an elastic frame work. It provides nearly 55% of the carbohydrate and 20% calories consumed globally” [2]. “It is cultivated worldwide and was one of the first crop to be domesticated some 10000 years ago” [3]. “It has been projected that the global wheat requirement for the year 2030 will increase to about 840 million tonnes while the wheat requirement for India for 2030 will be about 114.6 million ton” [4]

The most crucial fertilizer component for influencing wheat productivity is thought to be nitrogen. It is one of the main nutrients that, if not given in the right amounts, lowers wheat yield since plants require it for rapid growth and high production per hectare. Nitrogen is a basic component of protein, which is related to every essential process in a plant. “Proteins, phytochromes, chemicals, coenzymes, chlorophyll, and nucleic acids are all dependent on nitrogen. All the biochemical processes occurring in plants are mainly governed by nitrogen and its associated compounds which make it essential for the growth and development of wheat” [5]. “Therefore, it is necessary to apply nitrogenous fertilizer in the soil to get bumper yields of wheat” [6]. “Nitrogen insufficiency influences biomass synthesis and use of sun energy for productivity of the plant, with an extraordinary effect on grain yield and yield contributing parameters” [7]. Nitrogen deficiency in the soil causes the leaves become yellowing green, curled, wilted and dwarf. “The inconsistency in soil and climatic conditions related with forms that influence nitrogen elements in the root zone and their association with the plant may prompt variation in nitrogen accessibility and its necessity to plant” [8,9]. However, sometimes more application of nitrogen results in toxicity and harms the plant growth by making it more susceptible to lodging, causing environmental pollution through nitrate leaching [10] and volatilization in form of ammonia, which become a cause of high cost production resulting in less benefit to the farmers because only 1/3 part of applied nitrogenous fertilizer is taken-up by the cereal crops and assimilate it to their grains [11].

“Plant growth regulators have been recently reported to enhance growth and yield of wheat” [12]. There are several phases during the growth cycle where PGRs could be applied to modify plant growth and development. As a result, PGR’s can be applied to modify plant growth and development at different phases of the growth cycle. Chlormequat, also known as ChlorCholineChloride (CCC), serves as a major agricultural growth regulator in a number of countries. It is an organic chloride salt and a quaternary ammonium salt. Chlormequat chloride is an organic chloride salt comprising equal numbers of chlormequat and chloride ions. It has a role as a plant growth retardant and an agrochemical. After the use of Chlormequat chloride, it can effectively control plant growth, shorten the internodes of plants, make plant short, strong, thick, roots developed, resistant lodging, also darkening leaf color, thickening leaves, increased chlorophyll content, and increased photosynthesis, which increase the percentage of fruit set in certain crops, improve quality, and increase yield. “By applying CCC at the beginning of stem elongation and the other PGRs at later stage, prior to heading, cereal straw could be shortened” [13].

2. MATERIALS AND METHODS

The experiment was conducted at Abhilashi University, Chail chowk Mandi (H.P.) during the rabi season of 2022-2023. The soil of the experimental field was acidic in reaction (5.5), normal in EC (.024) and medium in organic carbon (.75). The experiment consists of seven treatments viz: T_1- control, T_2- 50% RDN (N_{60}, P_{60}, K_{40}), T_3- 75% RDN (N_{90}, P_{60}, K_{40}), T_4- 100% RDN (N_{120}, P_{60}, K_{40}), T_5- 125% RDN (N_{150}, P_{60}, K_{40}), T_6- 125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%), and T_7- 150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%) at 30. 60, 90 DAS and at harvest. The experiment was laid out in a randomized block design with three replications. Wheat cultivar PBW343 was sown on 10th November 2022 and harvested on 18.5.2023. Wheat seed @ 100 kg ha^{-1} was sown at a row to row spacing of 22.5 cm. Urea, DAP and MOP were used as the source of nitrogen, phosphorus and potash respectively. The crop received six irrigations at CRI stage, tillering stage, jointing stage, flowering stage, milking stage, dough stage. The effect of different levels of nitrogen and plant growth regulator recorded on different characters of wheat *viz,* Plant height (cm), Number of tillers (m^{-2}), Dry matter accumulation (g m^{-2}), Number of effective tillers (m^{-2}), Number of spikes (m^{-2}), Spike length (cm), Number of grains per spikes (m^{-2}), Test weight (g), Grain yield (q ha^{-1}), Straw yield (q ha^{-1}), Biological yield (q ha^{-1}), Harvest index (%).

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Plant height of wheat was recorded at 30, 60, 90 DAS and at harvest. The results are shown in Table 1 and Fig. 1. Data are presented in Table 1 revealed that different nitrogen levels and plant growth regulator significantly affected plant height at different growth stages except at 30 days stage. An examination of data on effect of nitrogen and plant growth regulator on plant height was found significant at 60, 90 DAS and at harvest. Maximum plant height (55.11, 83.27 and 108.54 cm) was recorded from treatment T_5 which is 125% RDN (N_{150}, P_{60}, K_{40}) which was on par with treatment T_4 100% RDN (N_{120}, P_{60}, K_{40}) (51.66, 79.78 and 104.25 cm) while minimum plant height was recorded from treatment T_1 Control (29.13, 61.35 and 75.46 cm). During the experimentation, the plant height followed a pattern at 30, 60, 90 DAS and at harvest is $T_5>T_4>T_7>T_6>T_3>T_2>T_1$.

The unusual decline in plant height was found in T_6 and T_7 as compared with the average height of the variety under investigation. This might be due to use of plant growth regulator (Chlormequat chloride) that reduced the plant height by inhibiting cell elongation and disrupting the biosynthesis of the gibberellin pathway. Similar findings have been reported by Shekoofa and Emam [14]. The increase in plant height was because nitrogen increases leaf area which results in high rate of photosynthesis, more production of assimilates and plant dry matter. These results are similar to Liaqat et al., [15] who also reported that plant height was significantly increased by different doses of nitrogen.

3.2 Number of Tillers (m^{-2})

Data pertaining to number of tillers as influenced by different experimental treatments have been presented in Table 2 and illustrated through Fig. 2 was recorded at 30, 60, 90 DAS and at harvesting stage.

Critical analysis of data shows that effect of different doses of nitrogen and plant growth regulator had non-significant effect on number of tillers at 30 DAS whereas at 60, 90 DAS and at harvest affected significantly. The number of tillers m^{-2} at 60, 90 DAS and at harvest was found significantly higher at treatment T_7 which is 150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%) (496.89, 470.38

and 453.04 m^{-2}) over the rest of the treatments and was at par with treatment T_6 125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%) (479.12, 448.75 and 427.84 m^{-2}) while the minimum number of tillers were found in treatment T_1 (179.31, 175.35 and 168.02). At 60 DAS, the highest number of tillers was recorded, except other stages of crop development. The treatments of the investigation followed a pattern of T_7>T_6>T_5>T_4>T_3>T_2>T_1.

From the data it is evident that no. of tillers increased in early stage and decrease in later stage. There was a steady increase in the number of tillers up to 60 DAS of the crop and declined thereafter. The reduction in number of tillers after 90 DAS was because of the aging and senescence, which was responsible for drying of tillers. Another reason was that plants have a definite tillering period after which they entered into the shoot elongation and ripening stage and the new tillers did not get time to develop. "The increase in the tiller production was most probably due to greater supply of nitrogen and other nutrients to be used for cell multiplication and enlargement and also for the formation of vital compounds in the cell sap. Similar findings were also reported by" Waraich et al., [16] and Mattas et al., [17]. "Increased levels of nitrogen resulted in reduction of mortality of tillers and produced more tillers from the main stem. These results are confirmatory to those revealed by" Liaqat et al., [15] and Kumar et al., [18].

Table 1. Effect of different levels of nitrogen and plant growth regulator on plant height (cm) at various stages of the crop

Sr. No.	Treatments	30 DAS	60 DAS	90 DAS	At harvest
T_1	Control	20.37	29.13	61.35	75.46
T_2	50% RDN (N_{60}, P_{60}, K_{40})	21.62	37.52	69.94	87.19
T_3	75% RDN (N_{90}, P_{60}, K_{40})	22.48	40.93	72.18	91.34
T_4	100% RDN (N_{120}, P_{60}, K_{40})	24.31	51.66	79.78	104.25
T_5	125% RDN (N_{150}, P_{60}, K_{40})	24.76	55.11	83.27	108.54
T_6	125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%)	23.12	44.24	74.55	95.48
T_7	150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%)	23.80	49.16	76.26	98.87
SEm ±		0.95	1.35	2.19	2.86
CD (P= .05)		NS	4.21	6.81	8.90

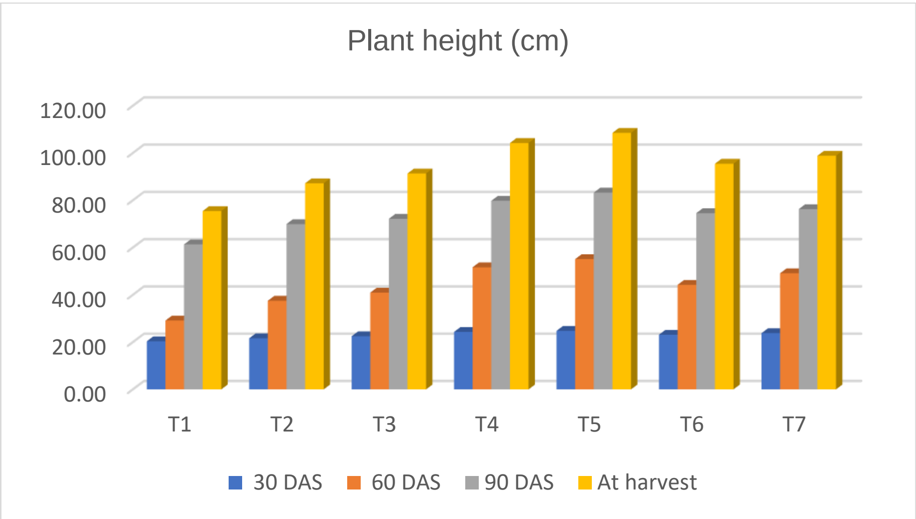

Fig. 1. Effect of different levels of nitrogen and plant growth regulator on plant height (cm) at various stages of the crop

Table 2. Effect of different levels of nitrogen and plant growth regulator on number of tillers (m^{-2}) at various stages of the crop

Sr. No.	Treatments	30 DAS	60 DAS	90 DAS	At harvest
T_1	Control	160.45	179.31	175.35	168.02
T_2	50% RDN (N_{60}, P_{60}, K_{40})	175.94	248.28	240.93	227.52
T_3	75% RDN (N_{90}, P_{60}, K_{40})	178.31	300.87	288.28	275.29
T_4	100% RDN (N_{120}, P_{60}, K_{40})	181.56	364.95	355.72	341.30
T_5	125% RDN (N_{150}, P_{60}, K_{40})	182.77	412.32	402.22	386.88
T_6	125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%)	183.62	479.12	448.75	427.84
T_7	150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%)	185.38	496.89	470.38	453.04
SEm±		5.31	10.41	10.24	9.51
CD (P= .05)		NS	32.42	31.91	29.62

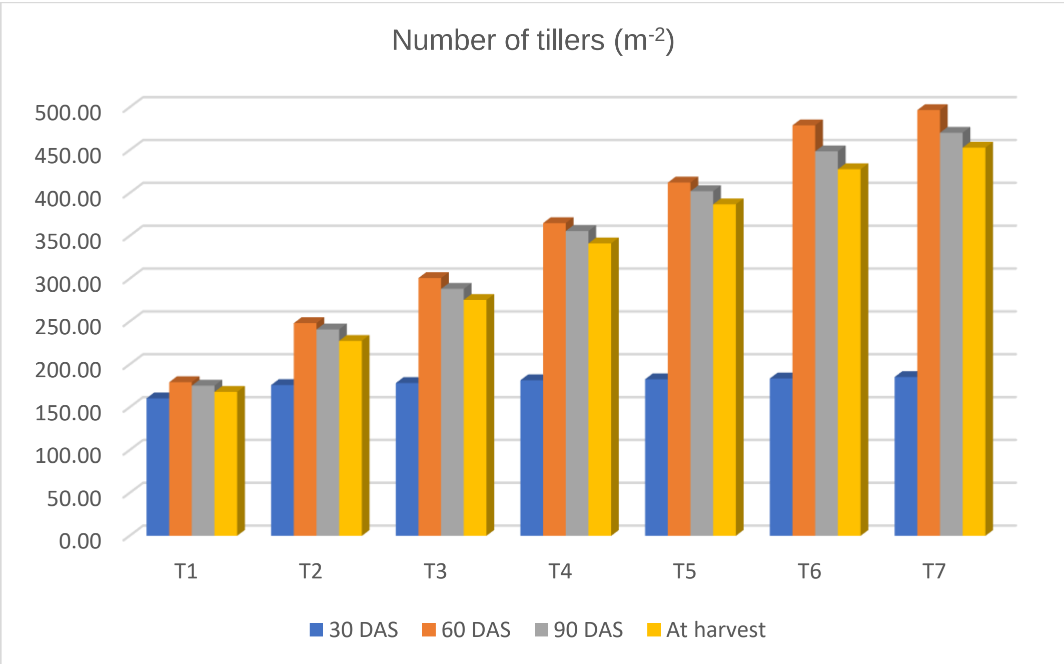

Fig. 2. Effect of different levels of nitrogen and plant growth regulator on number of tillers (m-2) at various stages of the crop

3.3 Dry Matter Accumulation (g m^{-2})

Data pertaining to dry matter accumulation influenced by different experimental treatments have been presented in Table 3 and depicted through Fig. 3 was recorded at 30, 60, 90 DAS and at harvesting stage.

Critical analysis of data revealed that effect of nitrogen and plant growth regulator has no significant effect on dry matter accumulation at 30 DAS. Data further reveals that the effect of nitrogen and plant growth regulator on dry matter accumulation at 60, 90 DAS and at harvest was found significant. Dry matter accumulation is the gain of dry weight by plant at specific time is influenced by complex of factors including internal and external system as well as dry matter accumulation is the combined effect of all growth characters *viz.* plant height, number of tillers. Dry weight of the above ground parts at harvest significantly higher with increased nitrogen levels, and was maximum in (T_7) 150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%) (502.71, 746.15 and 1011.86 g m^{-2}), which was at par with treatment (T_6) 125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%) (481.24, 724.10 and 987.33 g m^{-2}). However, the minimum dry matter accumulation was observed in treatment (T_1) (348.71, 553.19 and 789.14 g m^{-2}) which is control where neither nitrogen is given nor growth regulator is applied. Plant gains more weight with combined application of 150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%) as compared to the solo dose of nitrogen without PGR. The treatments of the investigation followed a pattern of $T_7>T_6>T_5>T_4>T_3>T_2>T_1$. The increase in dry matter accumulation might be due to better availability of nutrients and timely supply of fertilizers. These results are in close conformity with the observation of Chaturvedi [19], Singh and Yadav [20], Kumar et al., [18] and Shekoofa and Emam [14].

3.4 Number of Effective tillers (m^{-2})

The data on effect of different levels of nitrogen and growth regulators on number of effective tillers m^{-2} of wheat have been given in Table 4 and illustrated through Fig. 4.

The data revealed that treatment T_7 [application of 150% RDN (N_{180}, P_{60}, K_{40}) along with growth regulator (Chlormequat chloride 0.2%) (472.89)] significantly recorded maximum number of effective tillers m-2 which was found to be statistically at par with treatment T6 [125% RDN

Table 3. Effect of different levels of nitrogen and plant growth regulator on dry matter accumulation (g m-2) at various growth stages

Sr. No.	Treatments	30 DAS	60 DAS	90 DAS	At harvest
T_1	Control	60.94	348.71	553.19	789.14
T_2	50% RDN (N_{60}, P_{60}, K_{40})	61.52	377.76	599.75	875.80
T_3	75% RDN (N_{90}, P_{60}, K_{40})	61.73	392.18	613.85	907.68
T_4	100% RDN (N_{120}, P_{60}, K_{40})	62.23	412.16	647.09	920.23
T_5	125% RDN (N_{150}, P_{60}, K_{40})	62.50	459.13	681.48	948.03
T_6	125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%)	63.88	481.24	724.10	987.33
T_7	150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%)	64.56	502.71	746.15	1011.86
SEm±		1.85	12.98	20.28	16.99
CD (P=.05)		NS	40.44	63.19	52.93

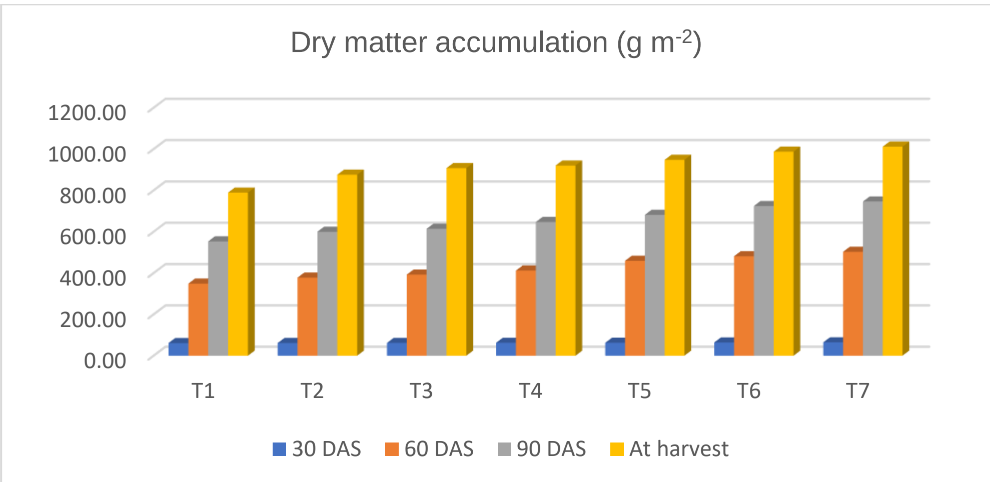

Fig. 3. Effect of different levels of nitrogen and plant growth regulator on dry matter accumulation (g m-2) at various growth stages

(N_{150}, P_{60}, K_{40}) along with growth regulator Chlormequat chloride 0.2% (455.12)]. Whereas, the minimum number of effective tillers are recorded from treatment T_1 control (161.26). A larger supply of nitrogen, is needed for cell expansion and multiplication as well as for the synthesis of nucleic acid and other critically crucial substances in the cell sap, is most likely that caused the increase in tiller production. 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. More tillering and improved plant development as a result of improved nutrition led to the production of more productive tillers in treatments with higher nutrient levels. Additionally, higher tiller density and higher nutrient levels have been found by other studies Mouriya et al., [21].

3.5 Number of Spikes (m^{-2})

Data pertaining to number of spike (m^{-2}) as influenced by different experimental treatments have been presented in Table 4 and delineated through Fig. 4 indicates that different levels of nitrogen and plant growth regulator (Chlormequat chloride 0.2%) had significant effect on number of spike m^{-2}.

Maximum number of spikes (469.82) were recorded in treatment T_7 150% RDN (N_{180}, P_{60}, K_{40}) along with growth regulator Chlormequat chloride 0.2% which is statistically at par with treatment T_6 125% RDN (N_{150}, P_{60}, K_{40}) along with growth regulator Chlormequat chloride 0.2% (453.02) and, the minimum number of spikes (157.81) were found in treatment T_1 control.

Many researchers concluded form their studies that if there is more absorption of nitrogen by the plants produces a greater number of spikes m^{-2}, enhanced vegetative growth and a greater number of tillers per unit area [22]; Nourmohammadi et al. [23].

3.6 Spike Length (cm)

Data recorded on length of spike (cm) as influenced by different experimental treatments have been presented in Table 4 and depicted through Fig. 4.

The data revealed that treatment T_7 with application of 150% RDN (N_{180}, P_{60}, K_{40}) along with growth regulator Chlormequat chloride 0.2% recorded significantly higher spike length (13.29 cm) which was statistically at par with T_6 125% RDN (N_{150}, P_{60}, K_{40}) along with growth regulator Chlormequat chloride 0.2% (13.15 cm) and the minimum spike length was recorded from treatment T_1 control (7.3 8 cm).

3.7 Number of Grains Per Spike (m^{-2})

Data pertaining to number of grains per spike^{-1}as influenced by different experimental treatments have been presented in Table 4 and illustrated through Fig. 4.

Critical analysis of data revealed that the number of grains spike^{-1} was not significantly influenced by the effect of nitrogen doses and plant growth regulator. Maximum number of grains per spike (42.58) was found under treatment T_7 150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator Chlormequat chloride 0.2%. However, the minimum number of grains per spike were recorded from the treatment T_1 (31.19). Nitrogen has mainly affected the vegetative growth of plant while at reproductive stage its role is less considerable that's why different levels of nitrogen did not affect the number of grains per spikes significantly. These results are in contradiction to Nerson et al., [24].

3.8 Test Weight (g)

Data recorded on test weight as influenced by different experimental treatments have been presented in Table 4 and depicted through Fig. 4.

Critical analysis of data revealed that effect of different doses of nitrogen and plant growth regulator did not significantly influence the test weight. However, maximum test weight was observed in treatment T_7 [150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator Chlormequat chloride 0.2% (43.78)] and was followed by T_6 [125% RDN (N_{150}, P_{60}, K_{40}) along with growth regulator Chlormequat chloride 0.2% (42.47), while where nothing is applied recorded the minimum test weight in treatment T_1 (37.51).

This finding can be explained by the fact that, as a result of the plants growing shorter, there was less competition for light absorption, improving photosynthesis and increasing the amount of photosynthates that accumulated in the grains [25]. Although the analysis revealed a rise in grain weight, the treatments had no discernible impact on the test weight.

Table 4. Effect of different levels of nitrogen and plant growth regulator on yield attributes of wheat crop

Sr. No.	Treatments	Number of effective tillers (m^{-2})	Number of spikes (m^{-2})	Spike length (cm)	Grains per spike (m^{-2})	Test weight (g)
T_1	Control	161.26	157.81	7.38	31.19	37.51
T_2	50% RDN (N_{60}, P_{60}, K_{40})	223.51	219.73	9.83	34.26	39.49
T_3	75% RDN (N_{90}, P_{60}, K_{40})	274.87	272.47	10.65	39.64	40.34
T_4	100% RDN (N_{120}, P_{60}, K_{40})	339.95	338.75	11.14	41.57	41.62
T_5	125% RDN (N_{150}, P_{60}, K_{40})	386.32	383.52	12.23	42.10	42.25
T_6	125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%)	455.12	453.02	13.15	42.36	42.47
T_7	150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%)	472.89	469.82	13.29	42.58	43.78
SEm±		10.13	9.47	0.34	3.00	1.27
CD (P= .05)		31.56	29.51	1.05	NS	NS

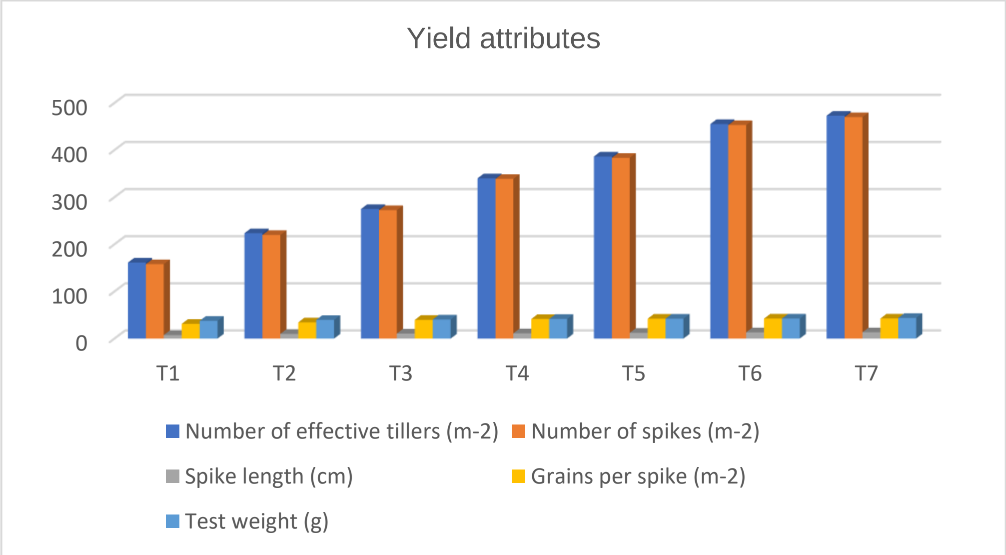

Fig. 4. Effect of different levels of nitrogen and plant growth regulator on yield attributes of wheat crop

3.9 Grain Yield (q ha^{-1})

Data recorded on grain yield (q ha^{-1}) as influenced by different experimental treatments have been presented in Table 5 and delineated through Fig. 5.

Wheat grain yield was also significantly influenced by different levels of nitrogen. Maximum grain yield (53.41 q ha^{-1}) was obtained from treatment T_7 [150% RDN (N_{180}, P_{60}, K_{40}) along with growth regulator Chlormequat chloride 0.2%] and is on par with treatment (T_6) 125% RDN (N_{150}, P_{60}, K_{40}) along with growth regulator Chlormequat chloride 0.2% (51.65 q ha^{-1}) while minimum grain yield (29.82 q ha^{-1}) was recorded from the control. Among the other treatments, T_5 was the highest and is on par with treatment $T_4 > T_3 > T_2 > T_1$.

"Plant growth regulator (Chlormequat chloride) reduce the plant height and this reduction played an important role in the increase of grain yield of wheat via. the alteration of dry matter partitioning into the spikes. Almost similar findings were reported by" Shekoofa and Emam [14]. Among all the essential nutrients applied to the plant nitrogen is the major one which has a key role in the process of photosynthesis. Increased rate of photosynthesis by the high dose of nitrogen gave more yield because large amount of dry matter, more assimilates were produced and transported to fill the seeds as a result of more applied nitrogen. "As such high fertility utilization and greater nutrient uptake favoured the plant growth and yield attributes and finally the grain and straw yield. The observations were in conformity with the findings of" Wang et al., [26].

3.10 Straw yield (q ha^{-1})

Data recorded on straw yield (q ha^{-1}) as influenced by different experimental treatments have been presented in Table 5 and delineated through Fig. 5.

A close perusal of data revealed that different treatments had significant influence on the straw yield of wheat. Wheat straw yield was also significantly increased by different levels of nitrogen. Maximum straw yield (65.85 q ha^{-1}) was obtained from treatment T_7 [150% RDN (N_{180}, P_{60}, K_{40}) along with growth regulator (Chlormequat chloride 0.2%)] which is at par with treatment T_6 [125% RDN (N_{150}, P_{60}, K_{40}) along with growth regulator Chlormequat chloride 0.2% (62.14 q ha^{-1})] while minimum grain yield (40.45 q ha^{-1}) was recorded from the control. This was due to the significantly highest of number of tillers m^{-2} and effective tiller m^{-2} recorded in this treatment. The lowest straw yield recorded in the control was due to the inability of the soil to provide adequate amount of nutrients to the plants in absence of applied fertilizers. This decreased nutrient delivery, especially in the early stages, caused slow initial growth and poor root development. These factors combined to cause poor growth all through the crop growth season, which led to a noticeably lower output of straw. Shahi et al., [27] have also published similar data demonstrating increased straw yields with the application of larger doses of fertilizers.

3.11 Biological Yield (q ha^{-1})

Data pertaining to biological yield (q ha^{-1}) as influenced by different experimental treatments have been presented in Table 5 and depicted through Fig. 5.

An examination of data on effect of different doses of nitrogen and plant growth regulator on biological yield was found significant. Maximum biological yield (119.26 q ha^{-1}) was found in treatment T_7 150% RDN (N_{180}, P_{60}, K_{40}) along with growth regulator Chlormequat chloride 0.2% which was statistically at par with treatment T_6 125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator Chlormequat chloride 0.2% (113.79 q ha^{-1}). However, the minimum biological yield (70.27 q ha^{-1}) was recorded from treatment T_1 control.

"More application of nitrogen gave tall plants, more grain yield, number of tillers per unit and total dry matter which collectively resulted in higher biological yield. There are many studies which revealed that with increasing the nitrogen rate biological yield increased" [28]. "During pollination high levels of nitrogen increased the total dry matter that help to get more grain yield" McDonald [29]. "Many other scientists reported that high levels of nitrogen yield in more straw and grain weight" [30]. As a result of more biological yield a plant with its large canopy is able to intercepts more sun radiation and produce more assimilates.

3.12 Harvest Index (%)

Data pertaining to harvest index (%) as influenced by different experimental treatments have been presented in Table 5 and illustrated through Fig. 5. Critical analysis of data revealed that effect of nitrogen and plant growth regulator has non-significantly influenced the harvest index.

Table 5. Effect of different levels of nitrogen and plant growth regulator on grain yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%) of crop

Sr. No.	Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
T_1	Control	29.82	40.45	70.27	42.43
T_2	50% RDN (N_{60}, P_{60}, K_{40})	34.25	47.31	81.56	41.99
T_3	75% RDN (N_{90}, P_{60}, K_{40})	37.41	51.79	89.20	41.94
T_4	100% RDN (N_{120}, P_{60}, K_{40})	41.12	54.37	95.49	43.06
T_5	125% RDN (N_{150}, P_{60}, K_{40})	45.06	59.86	104.92	42.95
T_6	125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%)	51.65	62.14	113.79	45.39
T_7	150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%)	53.41	65.85	119.26	44.78
SEm±		1.23	1.66	3.01	1.36
CD (P= .05)		3.83	5.17	9.38	NS

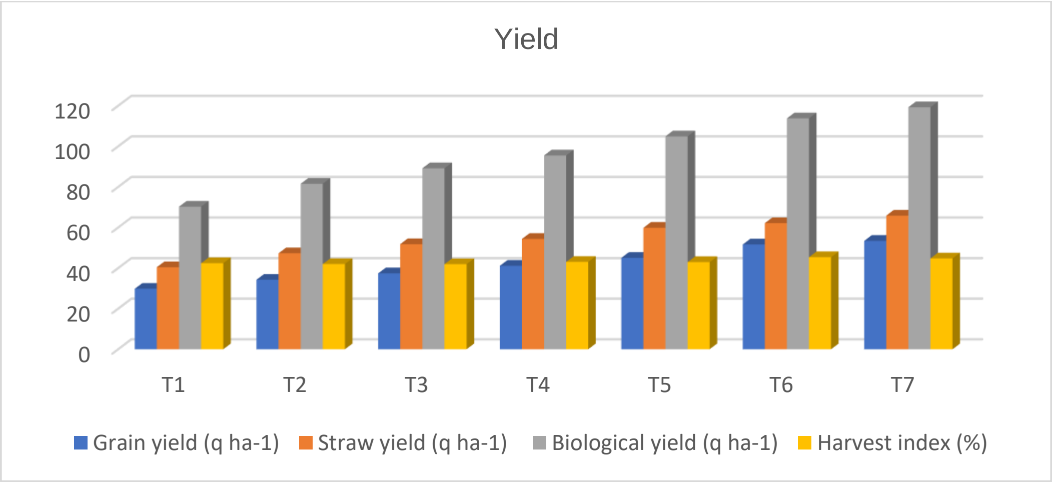

Fig. 5. Effect of different levels of nitrogen and plant growth regulator on grain yield (q ha-1), straw yield (q ha-1), biological yield (q ha-1) and harvest index (%) of crop

Maximum harvest index (45.39) was calculated from treatment T_6 125% RDN (N_{150}, P_{60}, K_{40}) with growth regulator Chlormequat chloride 0.2%. Whereas, the minimum harvest index was recorded from treatment T_3 75% RDN (N_{90}, P_{60}, K_{40}) (41.94).

A low harvest index indicates that fewer assimilates are being translocated from the source to the sink, which slows down seed development and causes them to shrink in size. A high harvest index indicates better development and filling because more assimilates were transferred from the source to the grains. The plant dry matter and grain weight, which ultimately depend on the availability and uptake of nutrients, particularly nitrogen, are closely correlated with the harvest index. Growth and development will increase with nitrogen levels, but only to a certain extent. Above that point, nitrogen can be harmful to plants and lower yield [31-34].

4. CONCLUSION

The scrutiny of data on growth parameters [*viz.,* plant height (cm), number of tillers (m^{-2}) and dry matter accumulation (g m^{-2})], yield attributes [*viz.,* effective tillers (m^{-2}), number of spikes (m^{-2}), spike length (cm), grains per spike (m^{-2}), and test weight (g)] and yields viz., grain yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%)]clearly reveals that the application of 150% RDN (N_{180}, P_{60}, K_{40}) with growth regulator (Chlormequat chloride 0.2%) (T_7) gave higher values of growth, yield attributes and yields.

The application of plant growth regulator (Chlormequat chloride 0.2%) decreased plant height while increasing biological yield, suggesting that more robust stem production is occurring. This, in turn, lowers the likelihood of lodging up to the application of 150% RDN (N180, P60, K40) with growth regulator (Chlormequat chloride 0.2%) and produces the maximum grain yield. To achieve the highest possible wheat yield, a 150% recommended dose of N combined with a growth regulator (Chlormequat chloride, 0.2%) is advised.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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