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Effect of nitrogen levels and plant growth regulators on growth, lodging, yield and economics of wheat (*Triticum aestivum* L.)

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Abstract
The influence of rate of N application and PGRs on Wheat (*Triticum aesitivum* L.) morphogenesis, yield and economics was studied under field condition at Agricultural Research Farm of Institute of Agricultural Sciences, B.H.U-Varanasi in *Rabi* season of 2015-16. The experiment with twelve treatments consisted of four nitrogen levels (0, 150, 180, 220 kg N ha^{-1}) as alone and in combination with two PGRs spray namely Chlormequat chloride applied as single @ 0.2% at 45 DAS and in combination with Tebuconazole as Chlormequat chloride @ 0.2% at 45 DAS followed by Tebuconazole @ 0.1% at 70 DAS. Nitrogen rates significantly affected growth characters, lodging, yield and economics as alone and in combination with PGRs, each treatment was replicated thrice in completely randomized block design. The results revealed that, higher plant height, tiller number, leaf area index, dry matter and lodging value recorded with higher dose of nitrogen *i.e.* 220 kg N ha^{-1} but higher grain yield, HI and gross return was obtained with marginally higher nitrogen rate *i.e.*180 kg N ha^{-1} while higher straw yield, net return and B:C ratio with optimum nitrogen rate *i.e.* 180 kg N ha^{-1}. PGR treatments significantly reduced plant height, leaf area index, increased tillering, and dry matter accumulation. They had significant effect on lodging score even at higher nitrogen rates and had obvious effect on the final yield and economics. The combined application of two sprays of Chlormequat chloride and Tebuconazole at different rates of N significantly reduced plant height, LAI, dry matter and lodging score as well as increased tiller number over nitrogen rates alone and insignificant to nitrogen with two sprays of Chlormequat chloride. In overall, application of 180 kg N ha^{-1}+ Chlormequat chloride+Tebuconazole recorded higher grain yield (48.37 q ha^{-1}), harvest index (40.52), gross return (116376.25 ha^{-1}), cost of cultivation (34212 ha^{-1}), net return (82164.25 ha^{-1}) and B:C ratio (2.40) while, 150 kg N ha^{-1} recorded maximum straw yield (73.45 q ha^{-1}. However, treatment T_{10}: 150 kg N ha^{-1}+ Chlormequat chloride+Tebuconazole recorded maximum B:C ratio (2.42), considered to be most remunerative for wheat cultivation in farmer's perspective but at marginally increased nitrogen *i.e.* 180 kg N ha^{-1}+ Chlormequat chloride+Tebuconazole have certain grain quality significance as well as maintains nitrogen balance in soil, preferred for cultivation.

Keywords: Nitrogen, PGRs, chlormequat chloride, tebuconazole, lodging, wheat (*Triticum aesitivum* L.).

1. Introduction
Lodging is defined as the permanent displacement of plant stems from their vertical position (Pinthus, 1973) [25] as a result of wind acting on the shoot and rain or irrigation weakening the soil and reducing anchorage strength (Berry *et al.*, 2004) [5]. Lodging affects all cereal species and many other crops, such as oilseed rape and sunflowers, throughout the world. Stem lodging in wheat (*Triticum aestivum* L.) is a major agronomic problem that has far-reaching economic consequences. However, it usually occurs only after the ear or panicle has emerged and results in the shoots permanently leaning or lying horizontally on the ground. Lodging severely affects the yield and the losses vary depending upon the intensity of lodging and stage at which lodging occurs. Lodging results in poor grain filling, reduces the grain quality, interferes with nutrient uptake and reduces mechanical harvesting efficiency (Acreche and Slafer, 2011) [1]. In India about 8.3 % yield losses in wheat occur due to lodging (Tripathi *et al.*, 2004). In recent past, during *Rabi* 2014-15, about 6.3-million-hectare area under wheat suffered significantly due to crop lodging and total production loss was about 9.32 million tons compared to 2013-14. Lodging is a complicated phenomenon which is influenced by many environmental factors like wind, rainfall, topography, soil type, previous crop management and diseases. Besides these factors, many morphological and anatomical plant traits like plant height, inter-node length, stem thickness, wall thickness as well as breaking strength, plant density, culm anatomy and chemical compositions of stem and root characters, head density and size affect lodging in crops. However, improving the lodging resistance of crops by

reducing plant height is only possible up to a certain limit in current crop production. Therefore, determining how to improve stem quality, especially the mechanical strength of the basal culm, has become the main target for increasing crop lodging resistance and thus grain yield. Many regions in India, where wheat is generally seeded on flat beds, flood irrigated and occurrence of high wind during grain filling, farmers skip the last irrigation to avoid lodging in wheat; which leads to poor grain filling and ultimately low yields (Hobbs *et al.*, 1998) [21].

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) [24]. 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 (Garg *et al.*, 1973; Fisher and Stapper, 1987) [16, 14]. Increased lodging in wheat has been reported to be associated with increased plant height, increased lower inter-node length, reduced development of secondary roots (anchorage) and increased shoot: root ratio (Berry *et al.*, 2004; Rajkumara, 2008) [5, 28]. Therefore, plant height especially culm length, is considered to be one of the major factors associated with lodging sensitivity (Berry *et al.*, 2000) [4]. Thus, lodging can be effectively managed by manipulating the plant height. Various agronomic practices like optimum seed rate, balanced fertilizer dose, proper irrigation, method of sowing; blending of varieties of different height and management of weeds, insects and diseases protects or minimize lodging.

Potential use of plant growth regulators (PGRs) and related compounds are known to minimize the lodging as they reduce the plant height (Cox and Otis, 1989). The synthetic plant growth regulators (PGRs) such as Chlormequat chloride (CCC), ethephon, trinexepac-ethyl and prohexadione-calcium have been found to reduce lodging risk by stem elongation (Rajala *et al.*, 2002) [26], thus the providing an opportunity to culivation of lodging susceptible, adapted high yielding cultivars under higher input use. However, the literatures on response of PGR effects on grain yield are variable from reduction in yield (Green, 1985) [18], significant increase in yield (Rowland, 1973) [30] to no effect (Whitely and Meridith, 1983). Disease infestation besides weak culms, genetic traits or insect attack also contributes stem lodging in wheat (Pinthus, 1973) [25]. Thus, fungicides are applied to avoid disease related yield losses and enhance grain yields by simply prolonging grain filling period and increasing kernel weights (Bertelsen *et al.*, 2002; Dimmock and Gooding, 2002) [6, 10]. Therefore, research on role of growth regulators and fungicides on wheat lodging at higher nitrogen rates are of paramount important to achieve targeted yields. Keeping above facts in view an experiment was laid out on "Effect of nitrogen levels and plant growth regulators on growth, lodging, yield and economics of wheat (*Triticum aestivum* L.)".

2. Experimental method

2.1 Description of the study site

One year, field experiment was conducted during the *Rabi* season of 2015–2016 in Agricultural Research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi at 25^{0}18' N latitude and 83^{0}03'E longitude and at an altitude of 80.71 meter above the mean sea level in the center of North-Gangatic Alluvial plain. The annual precipitation is about 850mm to 1000mm. Prior to establishment of experiment, surface (0–20 cm) soil samples, from ten spots across the experimental field, were collected, composited and analyzed for soil physicochemical properties and characterizing that the soil type at the experimental cite was a sandy loam under textural class with near to neutral in nature (pH 7.2), bulk density of 1.44 g cm^{-3} and organic carbon (0.44%) as well as organic matter of (0.76%), available N (196.4 kg ha^{-1}), available P (25.6 kg ha^{-1}), available K (170.1 kg ha^{-1}). The field had been used for experimental wheat crop cultivation under *kharif* rice as well as *rabi* wheat or barley in alternate years from the year of 2008 to till now. Thus, it is quite evident from the cropping history of the experimental site that the field has been continuously under cereals that is rice-wheat or rice- barley cropping sequence and its fertility set up has not been disturbed. Therefore, the field is ideally suited for the experiment. The air temperature, rainfall as well as meteorological parameters observed during the wheat crop development period in 2015-16 are shown in Figure 1.

2.2 Treatments and experimental design

The treatments consisted of random combinations of four N fertilizer rates (0, 150, 180 and 220 kg ha^{-1}) as alone and in conjugation with two plant growth regulators (Chloremequat chloride 0.2% spray at 45 & 70 DAS and Chloremequat chloride 0.2% + Tebuconazol 0.1% spray at 45 & 70 DAS) enlisted in Table. 1 were laid out in a randomized complete block design (RCBD) with three replications. The plot size for planting was 2.20 m×8.50m (18.7m²) accommodating 11 rows spaced 20 cm apart. Nine central rows with a net plot size of 14.4 m^2 were used for data collection and measurement. The distance between the plots and blocks were kept at 0.5 m and 1 m apart, respectively.

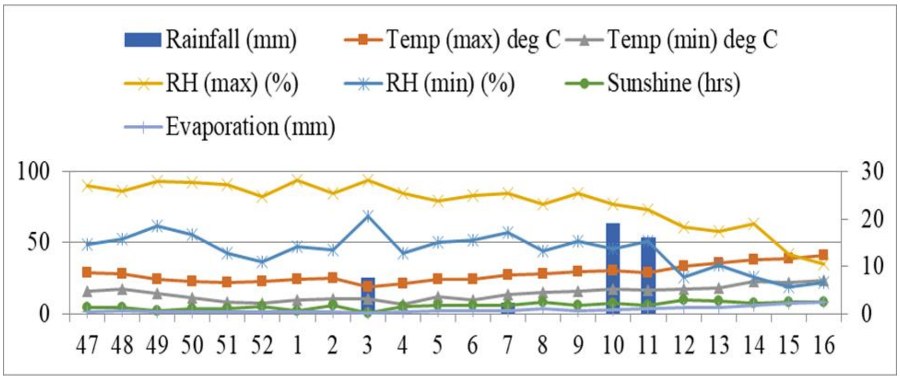

Fig 1: Mean standard week-wise meteorological parameters during crop season (*Rabi*), 2015-2016.

Table 1: Description of treatments adopted for experiment

Symbol	Treatment	Rate & time
T_1	Absolute Control	
T_2	150 kg N ha^{-1}	
T_3	180 kg N ha^{-1}	
T_4	220 kg N ha^{-1}	
T_5	T1 + Chloremequat chloride	0.2% at 45 & 70 DAS
T_6	T_2 + Chloremequat chloride	0.2% at 45 & 70 DAS
T_7	T3 + Chloremequat chloride	0.2% at 45 & 70 DAS
T_8	T4 + Chloremequat chloride	0.2% at 45 & 70 DAS
T_9	T1 + Chloremequat chloride + Tebuconazol	0.2% + 0.1% at 45 & 70 DAS
T_{10}	T2 + Chloremequat chloride + Tebuconazol	0.2% + 0.1% at 45 & 70 DAS
T_{11}	T3 + Chloremequat chloride + Tebuconazol	0.2% + 0.1% at 45 & 70 DAS
T_{12}	T4 + Chloremequat chloride + Tebuconazol	0.2% + 0.1% at 45 & 70 DAS

2.3 Description of the experimental materials
A double dwarf wheat variety HD-2967 (Pusa Sindhu Ganga) developed from IARI, New Delhi and released in the year 2009 was used, which have an average plant height of 101 cm. At 20 cm row spacing crop was sown 20 November 2015 with similar package and practices except treatment inputs. The control of pests, disease, and weeds were carried out according to the needs of the wheat crop, so as to enable adequate development of the plants to achieve the maximum grain yield potential.

2.4 Experimental procedures
The experimental plots were prepared by tractor ploughing and two times harrowing. In accordance with the specifications of the design, a field layout was prepared and each treatment was assigned randomly to experimental plots within each block independently. Wheat seed was sown by drilling in rows at the recommended rate of 125 kg ha^{-1} on November 20th in year, 2015. All the wheat plots were supplied with 60 kg P_2O_5 and 60 kg K_2O ha^{-1} through di-ammonium phosphate (DAP) and muriate of potash (MOP) as basal application whereas, nitrogen was applied in split, *i.e.*, one third at sowing by means of DAP + Urea and the remained nitrogen by using *Nutrient–Expert* decision support system software. Remaining one third of nitrogen was applied after first irrigation and rest nitrogen at the time of 50 day after sowing through urea. Plots were kept free of weeds by two hand weeding. No insecticide or fungicide was applied except treatment application, since there was no outbreak of insects or diseases. Harvesting was done manually using hand sickle.

2.5 Plant sampling and analysis
For recording biometric observations at a regular interval of 30th, 60th, 90th days after sowing and at harvest, ten plants from the net plot area randomly selected and tagged. However, for the dry matter accumulation, plants were taken at ground level from 1m row length of both sides and suddenly oven dried after sample collection to avoid plant respiration. At crop maturity, lodging observations were worked out by taking lodging area (%) and lodging angle at harvesting time. Further, lodging score was found by estimating the percentage area of plot that lodged and the angle of stem lodging (Fischer *et al.*, 1987) [14].

$$\text{Lodging score} = \frac{\%\text{ plot area lodged x angle of lodging from vertical}}{90}$$

At harvest stage, subsamples from each net plot were harvested at ground level and sun dried until constant weight was reached followed by total weight taken. Grain from samples were separated by threshing and grain and straw weight obtained separately followed by harvest index worked out by using given formula of Donald & Hamblin (1976) [11].

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield (grain + straw)}} \times 100$$

2.6 Data analysis
The observation recorded during the course of investigation were tabulated and analyzed statistically to draw a valid conclusion. The data were analyzed as per the standard procedure for "Analysis of Variance" (ANOVA) as described by Gomez and Gomez (1984) [17]. The 'F' test used to test treatment's and standard error of mean was computed in all cases. The difference in the treatments mean were tested by using Least Significant Difference (LSD) at 5% level of probability where 'F' test showed significant difference among means.

3. Experimental result and discussion
3.1 Plant height
Although height of wheat plants is controlled mainly by genetic factors (Gale and Yossefian 1985), it varies with growing conditions such as nutrition, water and radiation. It was reported that N nutrition greatly affects plant height probably through increasing gibberellin synthesis (Treharne *et al.*, 1985) [34]. Both the treatments nitrogen and growth regulators had significant effects on the plant; nitrogen increased the plant height around 17.94% by higher dose of nitrogen (T_4) over absolute control treatment (T_1), this might be due to increased protein synthesis and protoplasm that led to increase in cell size and was finally greater vertical development of plant. This observation is in conformity with the findings of Mosalem *et al.*, (2002) and Singh *et al.*, (2001) [23, 32]. On the other hand, plant growth regulators showing significant reduction in plant height even at higher doses of nitrogen *viz.* 87.40 cm in T_{12} and 93.63cm in T_8 in comparison to treatments T_1 to T_4 of nitrogen in alone. In nut, regarding combination of nitrogen level and growth regulators, 220 kg N ha^{-1} recorded higher plant height, but was statistically at par with other combinations of nitrogen and growth regulators. However, minimum plant height was recorded in all the growth regulators with control. Application of double PGRs enabled the plant for reduction of plant height over single PGRs but failed to touch the level of significance. 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) [3]. Similarly, double PGRs might be increased the effetiveness' over single PGRs.

Table 2: Effect of nitrogen levels and plant growth regulators on agronomic components and lodging score of wheat

Symbol	Plant height at harvest (cm)	Number of tillers m-2 at harvest	LAI at 90 DAS	Dry matter at harvest g m-2	Lodging score
T1	89.53	182.90	1.79	1329.95	0.00
T2	100.57	376.42	4.29	1493.84	9.17
T3	100.37	391.76	4.28	1490.87	10.43
T4	105.60	405.92	4.55	1568.61	21.57
T5	81.20	204.14	3.47	1206.16	0.00
T6	91.17	382.32	3.89	1354.21	5.67
T7	93.47	428.34	3.99	1388.38	8.63
T8	93.63	444.86	4.00	1390.85	20.50
T9	76.27	228.92	3.26	1132.88	0.00
T10	88.50	361.08	3.78	1314.60	4.77
T11	89.17	435.42	3.73	1324.50	4.83
T12	87.40	450.76	3.81	1298.26	16.43
SEm ±	2.82	6.84	0.13	41.88	0.39
CD (P=0.05)	8.27	20.05	0.39	122.82	1.13

3.2 Number of tillers
It is evident from the data that when growth regulators were not applied, significantly higher number of tillers were recorded at 220kg N ha^{-1} than 150 kg N ha^{-1} (T_2) and absolute control (T_1) but on par to 180 kg N ha^{-1}. 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) [37] and Gouping *et al.,* (2002). While in different combinations of nitrogen level and growth regulators differed significantly in respect of tiller production and both the growth regulator recorded significantly higher number of this attribute with increasing rate of nitrogen up to 180kg ha^{-1}. Among these, Chloremequat chloride+Tebuconazole at 220 kg N ha^{-1} ($T_{12)}$ recorded significantly higher number of tillers than rest of the treatment combinations, except 220 kg N ha^{-1} + Chloremequat chloride (T_8) and 180 kg N ha^{-1} + Chloremequat chloride + Tebuconazole (T_{11}). Whereas, among combinations of nitrogen levels and growth regulators, the minimum number of tillers was recorded with 150 kg N ha^{-1} + chloremequat chloride and in absolute control as CCC and Tebuconazole have stimulating tiller production property, similar findings were reported by Rodrigues *et al.,* (2003) [29].

3.3 Leaf area index
From critical screening of leaf are index data it has been found that maximum leaf area index with higher dose of nitrogen *i.e.* 220 kg ha^{--1} (T_4) which was at par to 180 kg N ha^{-1} (T_3) and 150 kg N ha^{-1}(T_2) but significantly superior over control treatment ^{1} (T_1). This might be due to higher N nutrition modified the leaf area of crop. Obviously, a high N nutrition at early growth stages as well as throughout growth period favored the enlargement of leaf area (Gouping *et al.,* 2001). Among the different combination of nitrogen level and growth regulators, Chloremequat chloride with 220 kg N ha^{-1} recorded significantly higher leaf area index, except, Chloremequat chloride + 150 kg N ha^{-1} (T_6) and Chloremequat chloride + 180 kg N ha^{-1} ((T_7) treatments. However, minimum leaf area index was recorded in all the growth regulators with control. Maximum leaf area index reduced when both the PGRs were sprayed in conjugation at all the levels of nitrogen. This might be due to PGRs in conjugation more effective to reduce cell division, reduction of leaf expansion because of inhibited gibberellin biosynthesis (Gouping *et al.,* 2001). It also confirms the result that growth regulator caused significant reduction in leaf area index at all the rates of nitrogen when compared with different rate of nitrogen without growth regulators.

3.4 Dry matter accumulation
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 and green leaves. Dry weight of the aboveground parts at harvest significantly higher with increased nitrogen levels, and was maximum in 220 kg N ha^{-1} (T_4), irrespective of the growth regulators. It is clear from the data that nitrogen rates from 150 to 220 kg N ha^{-1} remained on par to each other, but were significantly superior to control in respect of dry matter accumulation. This might be due to adequate supply of nutrients allowed the plant tissue to grow large and increase the chlorophyll formation and stimulated rapid rate of photosynthetic activity, consequently recorded more dry matter accumulation in comparison to its lower level (Ahmad *et al.,* 2011) [2]. In different combination of nitrogen level and growth regulators, higher dry matter was recorded with Chloremequat chloride + 220 kg N ha^{-1}, which was statistically on par with other combinations of nitrogen and growth regulators except PGRs conjugation to control treatment. Thus, significantly minimum dry matter was recorded in all the growth regulators without nitrogen. This might be due to use of growth regulators inhibit stem and coleoptiles elongation and reduce the plant height and leaf area index as well as leaf biomass which ultimately reduce dry matter accumulation (Clark and Fedak, 1977) [7]. Through table 1 it is clear that growth regulators caused significant reduction in dry matter accumulation with all the rates of nitrogen when compared with different rates of nitrogen alone because of inhibitory effect of PGRs on physiological processes in plant (Clark and Fedak, 1977) [7].

3.5 Lodging score
Stem lodging is usually caused by the weight of water accumulated in the mature ears, wind, and low stem resistance, among other factors (Taiz & Zeiger, 2004) [33]. Lodging score significantly increased with increase in nitrogen level, irrespective of the growth regulators. Among

nitrogen levels alone, significantly higher lodging score (21.57) was recorded with 220 kg N ha^{-1} (T_4) than rest of the treatment 10.43, 9.17 and 0.00. in (T_3), (T_2) and (T_1) respectively, of nitrogen level. The reason behind this due to increased plant height, reduced breaking strength of second inter-node and stem strength at higher doses of nitrogen (Crook and Ennos 1995) [9]. Among the different combination of nitrogen level and growth regulators, 220 kg N ha^{-1}+ Chloremequat chloride (T_8) recorded significantly higher lodging score as compare to rest of the treatments. However, combined application of Chloremequat chloride and Tebuconazole even with 220 kg N ha^{-1} recorded significantly lower lodging score as compare to application of Chloremequat chloride with 220 kg N ha^{-1} as in combination inhibited gibberellin biosynthesis by blocking of ent-kaurene synthesis from geranylgeranyl diphosphate as well as specifically it inhibited the activity of copalyl diphosphate synthase and on the other hand triazole group of fungicide also acting as growth retardant inhibited oxidation of ent-kaurene to ent-kaurenoic acid during stage 2 of gibberellin biosynthesis. Thus, they provide double action against height increase by shortening internode length (Espindula *et al.*, 2009) [12] resulted reduced lodging.

3.6 Effect on yield

Grain yield, straw yield and harvest index (HI) increased significantly with increasing nitrogen levels, maximum grain yield (43.47 q ha^{-1}) and HI (38.72) were recorded in 180 kg N ha^{-1} (T_3) which was significantly higher as compare to 220 kg N ha^{-1} (T_4) and control (T_1) but was on par with 150 kg N ha^{-1} (T_2) while, maximum straw yield (73.45) in T_2 significantly superior over T_4 and T_1 and at par to T_3 irrespective of growth regulators. This might be due to improvement in growth and yield attributing characters and higher photosynthetic activity. It is also well-known fact that with increasing level of fertilizer application, the intensity and nutrient supply capacity of soil increases. 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.,* (2012).

Table 2: Effect of nitrogen levels and plant growth regulators on yield of wheat

Symbol	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (q/ha)
T_1	27.83	47.20	37.10
T_2	41.70	73.45	36.21
T_3	43.47	68.85	38.72
T_4	36.47	66.55	35.40
T_5	29.37	53.95	35.24
T_6	45.97	72.15	38.93
T_7	46.63	72.76	39.07
T_8	37.30	66.85	35.81
T_9	31.50	59.18	34.74
T_{10}	47.17	73.12	39.24
T_{11}	48.37	71.02	40.52
T_{12}	39.90	68.40	36.85
SEm ±	0.98	1.75	0.67
CD (P=0.05)	2.88	5.14	1.95

Furthur, significantly higher grain yield (48.37q ha^{-1}) and HI (40.52) were recorded in Chloremequat chloride+Tebuconazole with 180 kg N ha^{-1} (T_{11}) than rest of the treatment combinations of nitrogen level and growth regulators, except T_6, T_7 and T_{10}. Maxumum straw yield (73.12 q ha^{-1}) was recorded with 150 kg N ha^{-1} + Chloremequat chloride+ Tebuconazol (T_{10}) significant to rest of treatment, except T_6, T_7, T_{11} and $T_{12.}$ However, lower grain yield was recorded in all the growth regulators without nitrogen. The results were in conformity with Wang *et al.*, (2012). The use of PGRs increased the grain yield compared to the control treatment by affecting the yield contributing traits and also reduced the plant height. By increasing the number and survival of effective tillers and leaf area, PGRs causes more photosynthesis and more assimilates are mobilized towards grains and lead to the increase of grain yield (Shekoofa and Emam, 2008) [31].

3.7 Economics

Economics of wheat cultivation as affected by the treatment of different nitrogen levels and combination of nitrogen levels and growth regulators as given in Table 3. Gross return, net return and benefit: cost ratio was affected by nitrogen (Table 3). It increased with increase in N rates and maximum gross and net return, B:C ratio was obtained from 150-180 kg N ha^{-1} varied in the range of 107662.50` ha$^{-1}$- 107601.75` ha^{-1} gross return, 74317.50` ha$^{-1}$- 73906.75` ha^{-1} net return and 2.23-2.19 B:C ratio, respectively. However, further increment of nitrogen dose *i.e.* 220 kg N ha^{-1} (T_4) resulted decreasing trend for gross return: 95516.75 ` ha$^{-1}$, net return: 61353.75` ha^{-1} and B:C ratio: 1.18. In nut, higher gross return and net return was recorded in 150 kg N ha^{-1} (T_2) followed by 180 kg N ha^{-1} (T_3). Whereas lowest gross return and net return was recorded in absolute control(T_1). It is evident from the results that N is positively correlated with B: C ratio and hence there was linear increase in B: C ratio with rising N rate up to optimum level followed by decreasing trend showed negative effect. The possible reason for variation in B: C ratio might be variation in yield due to different N rates, which means that increase in N up to optimum rate increased B: C ratio followed by declined in excessive nitrogen. However, lowest B:C ratio in control due to lowest yield. The findings were in agreement with Usman *et al.*, 2013 and Yousaf *et al.*, 2014 [22, 36]. Overall effect of nitrogen and PGRs in conjugation was significant. Favorable effect of PGRs with N revealed that gross return and net return obtained from 180 kg N ha^{-1} with Chloremequat chloride+ Tebuconazol (T_{11}) was quite higher to 150 kg N ha^{-1} with Chloremequat chloride+ Tebuconazol (T_{10}) followed by T_6 and T_7, as Chloremequat chloride alone with 150 and 180 kg N ha^{-1}, respectively. Regarding B:C ratio, application of 150 kg N ha^{-1} with Chloremequat chloride+ Tebuconazol (T_{10}) was most remunerative followed by T_{11} but the difference was very minor. Although, treatment T_{11}: 180 kg N ha^{-1} with Chloremequat chloride+ Tebuconazol have some other potential benefits, which may have significant economic and environmental impacts like crop lodging had been reduced, higher grain quality *i.e.* higher protein content, limited C emission, appropriate supply of N throughout life cycle and reduced risk of soil sickness, limited surface and ground water pollution, and thus 180 kg N ha^{-1} with two sprays of Chloremequat chloride + Tebuconazol application at 45 & 70 DAS may become several folds superior to 150 kg ha^{-1} with two sprays of Chloremequat chloride + Tebuconazol.

Table 3: Effect of nitrogen levels and plant growth regulators on economics of wheat

Treatment Symbol	Gross return (` ha^{-1})	Cost of cultivation (` ha^{-1})	Net return (` ha^{-1})	B:C ratio
T_1	70772	31346	39426	1.26
T_2	107662.50	33345	74317.50	2.23
T_3	107601.75	33695	73906.75	2.19
T_4	95516.75	34163	61353.75	1.80
T_5	77159.25	31862.50	45296.75	1.42
T_6	113394.25	33861.50	79532.75	2.35
T_7	114766.75	34211.50	80555.25	2.36
T_8	96992.50	34679.50	62313	1.80
T_9	83545.50	31863	51682.50	1.62
T_{10}	115806.25	33862	81944.25	2.42
T_{11}	116376.25	34212	82164.25	2.40
T_{12}	101887.50	34680	67207.50	1.94

4. Conclusion
On the basis of summarized results, it can be concluded that to protect wheat from lodging and for higher yield and income use of higher dose of nitrogen, 180kg N ha^{-1} with PGRs *viz.*, Chloremequat chloride + Tebuconazole use at 0.2% + 0.1% sprayed at 45 and 70 days after sowing is most appropriate for wheat cultivation under lodging prone condition.

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