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Effect of Growth Retardants under High Fertility Scenarios on Wheat Varieties

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Abstract: Wheat is a leading cereal and its lodging under high fertility conditions is a main concern which is responsible for its lower productivity. The field experiments were conducted during the year 2018-19 and 2019-20 at Regional Research Station, Gurdaspur to evaluate effect of growth retardants under high fertility levels on wheat varieties to achieve yield maximization. The experiment was laid out in a split plot design with three replications. The treatments consisted of three fertility levels in main plots viz. FL1- Recommended Fertilizer Dose (RFD), FL2- RFD+Farmyard Manure @ 15 t ha^{-1}, FL3-150% RFD+ FYM (15tha^{-1}) + applications of growth retardants (GR) and five varieties i.e. WH 1270, HD 2967, DBW 187, HD 3086 and DBW 303 in sub plots. Results of the study revealed that treatment FL3 recorded significantly higher effective tillers, grains per earhead, grain yield, biological yield and harvest Index in wheat genotypes in comparison to treatment FL1. The minimum mean lodging score with the applications of growth retardants in FL3 was noticed even at high dose of fertilization. Maximum grain yield and biological yield were registered with treatment FL3 which was 7.4 and 15.7 %, 2.0 and 8.0 %, 5.1 and 7.1% over FL2 and FL1, respectively. Among different wheat varieties, DBW 187 recorded highest grain yield followed by HD 3086, DBW 303, HD 2967 and WH1270, respectively. Hence, DBW 187 is the promising variety as there was no yield decline under high fertility conditions.

Keywords: Fertility levels, Growth retardants, Varieties, Wheat, Grain yield

To maximize wheat crop yield, adoption of intensive crop management practices using high doses of fertilizers, especially nitrogen is in practice. The higher fertilizer dose sometimes causes lodging due to more height and more tillering and is a major concern in high yielding systems. Lodging limits both productivity and quality of produce. Yield losses due to lodging stress are 8–80% in wheat (Acreche and Slafer 2011). One of the main factors limiting wheat productivity is lodging, which has caused harvestable yield losses of up to 80% (Foulkes et al. 2011). As the plant height is recognized as valuable trait to impart lodging resistance in cereals, so, lodging can be minimized by shortening of the plant height (Lu et al 2014, Kuai et al 2015). Moreover, lodging stress is a complex phenomenon which is influenced by many factors, including high plant populations, excessive use of nitrogenous fertilizers, heavy rains, strong winds, storm or hail, topography, soil type, tissue damage by insects, and diseases (Ye et al 2016). The yield potential of high yielding genotypes of wheat under irrigated and high input rates could be achieved consistently and efficiently by finding suitable solutions of lodging problem. In this context, the use of growth retardants found to be most effective for managing the problem of lodging. 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). Although growth retardants can reduce the risk of lodging but limited literature is available on their effectiveness on the culm height, physical strength and possible effects on minimizing the lodging risk and grain yield in wheat crop genotypes under higher nutrition level. Therefore, the present study was conducted to elucidate the effect of different fertility levels and use of growth retardants on different wheat varieties with contrasting traits.

MATERIAL AND METHODS

Study site: The field experiments were conducted at the research farm of PAU Regional Research Station, Gurdaspur (32°03' N, 75°25' E; a.m.s.l 261 m) during *Rabi* seasons of 2018-19 (S1) and 2019–2020 (S2). The experiment site represents the north Punjab region which is sub-mountainous undulating zone falls under zone II of agro-climatic zones. Most of the precipitation (68%) at Gurdaspur, with a normal annual rainfall of 980 mm, is received during the monsoon months (July-September). A substantial precipitation is also received during the winter wheat season due to sub-tropical climatic phenomena called western disturbances (WD).

Experimental details: The soil of experimental field was loam in texture with electrical conductivity (EC) of 0.19 dSm^{-1}, pH of 7.1, organic carbon (0.45 %), phosphorus (P) 20.0 kg ha^{-1} and potassium (K) 142.5 kg ha^{-1}. The experiments were conducted in split-plot design with three fertility levels i.e. FL1- Recommended fertilizer dose (RFD), FL2 – RFD+FYM (Farmyard Manure)15 t ha^{-1}, FL3-150% RFD+ FYM (15tha^{-1}) + applications of growth retardants(GR) in main plots and five varieties i.e. WH 1270, HD 2967, DBW 187, HD 3086 and DBW 303 in sub plots with three replications. The dose of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) were 125:62.5: 60 kg ha^{-1} and, 125: 62.5:60 kg ha^{-1} along with farmyard manure (FYM)15 t ha^{-1}, 187.5: 93.8: 90 along with FYM 15 t ha^{-1} in FL1, FL2 and FL3, respectively was applied before sowing of the crop whereas 1/3rd of N (urea), full P (diammonium phosphate), and K (muriate of potash) were applied at the time of sowing. The rest of the nitrogen was applied in two equal splits with one split application at first irrigation (crown root initiation stage) and second split application with second irrigation (maximum tillering stage). The different wheat varieties were sown on 20th October 2018 and on 22nd October 2019. The crop was sown in rows at 20 cm apart at depth of 4-6 cm. Growth retardant treatments included two sprays as tank mix application of Chlormequat chloride (Lihocin) @ 0.2% + tebuconazole (Folicur 430 SC) @ 0.1% of commercial product dose done at first node and flag leaf in each plot using knapsack sprayer on clear sunny days.

Growth parameters and yield attributes : The emergence count data was taken at 15 days after sowing by counting the number of plants per square meter from randomly selected 3 sites per plot and then average number of plants emerged per square meter. Other growth parameters and yield attributes were recorded at physiological maturity stage. The effective tillers were counted from per square meter from randomly selected 3 sites per plot and average was presented. Randomly ten ears were taken from each plot, threshed manually, counted, and averaged for calculating the number of grains per. A random sample of grain from each plot was taken. After harvesting manually, the bundles from each plot were weighed to record biological yield (kg/plot). At harvest time, the plant parameters recorded were plant height (cm), grain and straw yield (kg/ha). The plant's height was measured in cm using a metre scale from the base of the plant. The plants from each net plot were harvested and grains were separated by threshing, grain and straw yields obtained in each net plot were weighted (kg) and further it was calculated on the hectare basis (kg ha^{-1}).

Determination of lodging score: The percentage of the plot area lodged to the total area of the plot was recorded and presented as percent lodging (0–100%) of the plot. Lodging score was calculated based on the integral effect of lodging percentage and lodging.

$$\text{Lodging score} = \frac{\text{(Lodged area/Net plot area)} \text{ x angle of lodging}}{90} \text{x100}$$

RESULTS AND DISCUSSION

Effect of growing seasons on wheat growth and yield: A significant variation in emergence count, plant height and number of effective tillers of wheat between the seasons was observed (Table 1). However, number of grains per year was at par in both seasons as it is less influenced by environmental factors being a genetic character. The grain yield, biological yield and harvest index of the crop was significantly lower in S2 compared to S1 (Table 2). The percent deviation in yield and biomass production of wheat was - 26% and -23% in S2, respectively. In contrast, the lodging score was significantly higher in S2 irrespective of nutrient management dosages and wheat varieties. The favourable weather conditions during S1 played a major role in wheat crop growth and yield (Fig. 1). The S2 was warmer as compared to S1 during major growth phases which hampered the grain filling at later stages and produced less ear heads, grain yield and biological yield. The maximum day time air temperature coincides with heading to anthesis period (February month) of wheat, during S2, it was 3.1°C higher compared to S1. Higher day temperature might have affected the pollen growth and anthesis in S2 and hence produced less grain yield and low yield attributes (Djanaguiraman et al 2020). The total rainfall received during the wheat seasons was 364.7mm and 404.4 mm in S1 and S2, respectively. The rainfall during grain filling/maturity (March and April month) was 484% higher during S2 which led to more crop lodging and thus reduced wheat yield and harvest index during the season as compared to S1 (Niu et al 2016). The average bright sunshine hours were also higher during S1 (5.1) compared to S2 (4.0). Higher sunshine during S1 provided more photosynthetically active radiation (PAR) to accumulate more dry matter and grain yield (Ahmed and Hassan 2011).The maximum HI was during 2018-19 and it was significantly higher than 2019-20.

Effect of fertility levels and growth retardants on yield attributes of wheat: The treatment FL1 recorded significantly higher emergence count as compared to treatment FL3 but was at par with FL2. At harvest, FL2 recorded significantly higher plant height than FL1 followed by FL3. In the treatment FL3, minimum plant height was observed which might be due to spray of growth retardants at first node and flag leaf stage. Application of growth retardants in treatment FL3 significantly reduced plant height by 9.9 cm and 12.3 cm when compared to FL1 and FL2, respectively. The reduction in plant height also helped in lodging reduction and had a significant effect on effective tillers even at high nutrition. About 11.2 and 13.6 per cent higher effective tillers were recorded in treatment FL3 over FL2 and FL1, respectively. Maximum grains per ear head (48.0) were also in FL3 and were significantly higher than FL1 (44.2) and were at par with FL2 (46.3).The FL3 treatment recorded 7.41 and 15.7% higher grain yield than FL1 and FL2, respectively. The higher grain yield in FL3 treatment was due to the production of more effective tillers and grains per ear head. Balanced nutrition throughout growth stages of a plant, enables it to assimilate sufficient photosynthetic products and enhance dry matter accumulation (Khan et al 2014 and Yadav et al 2017). HI was significantly higher in treatments FL1 and FL2 as compared to FL3 whereas treatments FL2 and FL3 remained at par with each other.

Response of wheat genotypes to fertility levels and growth retardants: The emergence count did not vary significantly with respect to different wheat varieties. The wheat variety HD 3086 recorded minimum height and was significantly different in height from other varieties. However, height recorded in other varieties was at par with each other. Maximum effective tillers were recorded in HD 2967 and the

Table 1. Effect of high fertility levels and growth retardants on agro-morphological parameters

Treatment	Emergence count (n m^{-2})	Plant height (cm)	Effective tillers (n m^{-2})	Grains per earhead(n)
Seasons (S)				
2018-19	208.43a	90.16a	445.75a	44.55a
2019-20	180.17b	85.71a	338.61b	44.55a
Nutrient management level (FL)				
RFD (FL1)	200.35a	90.41b	372.55c	44.23b
RFD+FYM (FL2)	194.75ab	92.89a	380.64b	44.23b
150%RFD+FYM+GR (FL3)	187.8b	80.51c	423.35a	46.28ab
Varieties (V)				
WH 1270	192.47a	88.02a	393.52b	43.52c
HD 2967	193.42a	88.36a	410.14a	43.52c
DBW 187	193.28a	89.13a	385.72bc	43.97c
HD 3086	200.31a	84.11b	393.47b	45.33bc
DBW 303	192.03a	90.06a	378.06c	47.66b

Same alphabet in column do not differ significantly, Duncan Multiple Range Test (p-0.05)

Table 2. Effect of high fertility levels and growth retardants on wheat yield, yield attributes and lodging score

Treatments	Grain yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)	Lodging score
Seasons (S)				
2018-19	90.01a	235.41a	38.31a	0.47b
2019-20	66.55b	181.38b	36.88b	7.6a
Nutrient management levels (FL)				
RFD (FL1)	72.59c	199.15b	39.08a	4.07a
RFD+FYM (FL2)	78.21b	210.87ab	37.21b	4.03a
150%RFD+FYM+GR (FL3)	84.04a	215.15a	36.5b	4a
Varieties (V)				
WH 1270	76.09b	194.12b	39.34a	3.56b
HD 2967	77.23b	217.79a	35.31c	4.44a
DBW 187	82.23a	220.43a	37.21b	4.67a
HD 3086	78.29b	197.02b	39.77a	3.83b
DBW 303	77.56b	212.61a	36.36bc	3.67b

Same alphabet in column do not differ significantly, Duncan Multiple Range Test (p-0.05)

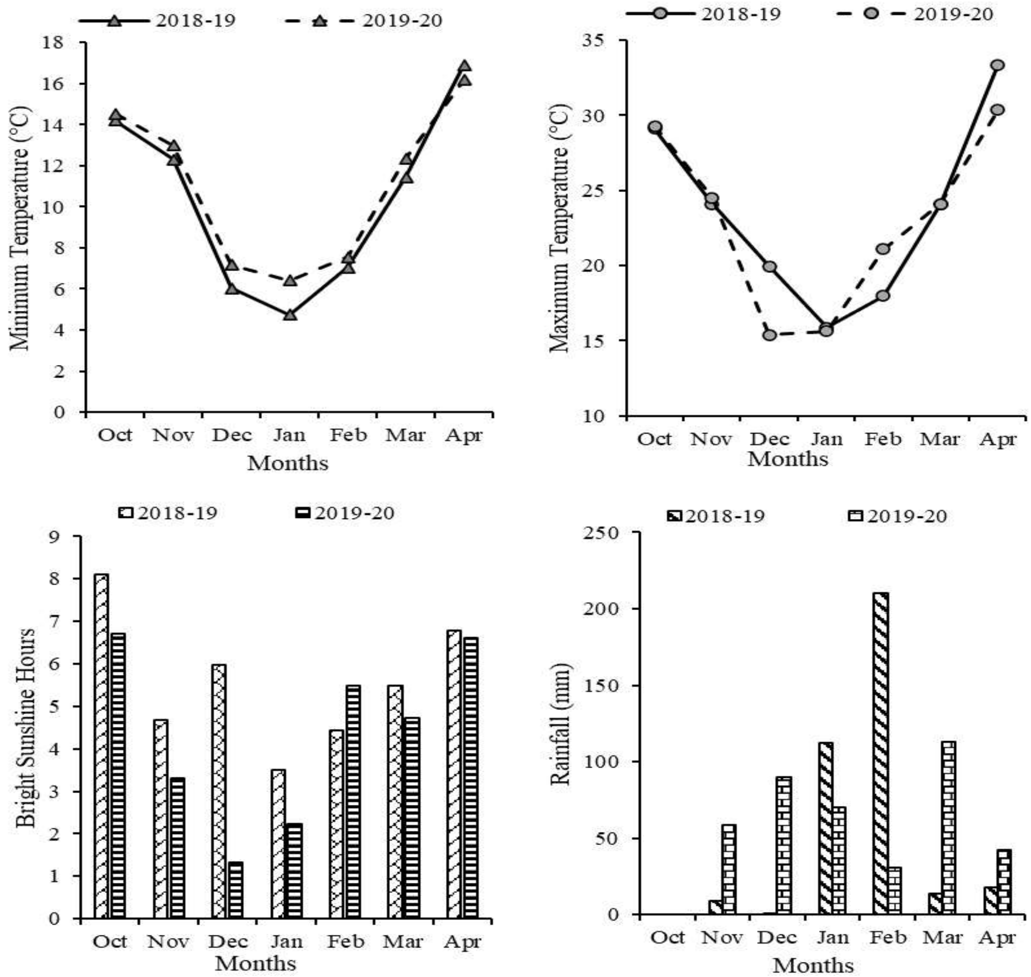

Fig. 1. Weather parameters during *Rabi* 2018-19 and 2019-20

other varieties WH 1270, HD 3086 and DBW 187 produced tillers which were at par to each other. Lowest earhead count was observed in variety DBW 303, but it recorded significantly higher grains per earhead as compared to other varieties. The highest grain yield and biological yield was recorded in wheat variety DBW 187. An increase of 5.12,5.72,6.47 and 8.01 % in yield of DBW 187 was observed over HD 3086, DBW303, HD 2967 and WH 1270, respectively. The variety HD 3086 recorded maximum HI (39.7%) followed by WH 1270 , DBW 187, DBW 303, and HD 2967.

Effect of fertility levels and growth retardants on lodging score of wheat: In the second year more lodging score (7.6) was observed as compared to first year (0.47) whereas different fertility level treatments recorded almost similar lodging score. Application of growth retardants in FL3, resulted in shortened plant height even at high fertilization and helped in reducing lodging score. Maximum lodging score was observed in variety DBW 187, might be due to more biological yield of crop.

CONCLUSIONS

The high fertility treatment 150% RFD+ FYM (15 t ha^{-1}) + applications of growth retardants recorded the highest grain yield and DBW 187 is the most suitable variety under high fertility conditions since there was no yield decline in the presence of high fertility.

REFERENCES

Acreche MM and Slafer GA 2011. Lodging yield penalties as affected by breeding in Mediterranean wheats. *Field Crops Research* **122**(1): 40-48.

Ahmed M and Hassan FU 2011. Cumulative effect of temperature and solar radiation on wheat yield. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* **39**(2): 146-152.

Djanaguiraman M, Narayanan S, Erdayani E and Prasad PV 2020. Effects of high temperature stress during anthesis and grain filling periods on photosynthesis, lipids and grain yield in wheat. *BMC Plant Biology* **20**(268): 1-12.

Foulkes MJ, Slafer GA, Davies WJ, Berry PM, Sylvester-Bradley R, Martre P, Calderini DF, Griffiths S and Reynolds MP 2011. Raising yield potential of wheat. III. Optimizing partitioning to grain while maintaining lodging resistance. *Journal of Experimental Botany* **62**(2): 469-486.

Khan AA, Inamullah and Jan MT 2014. Impact of various nitrogen and potassium levels and application methods on grain yield and yield attributes of wheat. *Sarhad Journal of Agriculture* **30**(1): 35-36.

Kuai J, Yang Y, Sun Y, Zhou G, Zuo Q, Wu J and Ling X 2015. Paclobutrazol increases canola seed yield by enhancing lodging and pod shatter resistance in *Brassica napus* L. *Field Crops Research* **180**: 10-20.

Lu D, Lu F, Yan P, Cui Z and Chen X 2014. Elucidating population establishment associated with N management and cultivars for wheat production in China. *Field Crops Research* **163**: 81-89.

Niu L, Feng S, Ding W and Li G 2016. Influence of Speed and Rainfall on Large-Scale Wheat Lodging from 2007 to 2014 in China. *PLoS ONE* **11**(7): e0157677.

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Yadav SK, Singh G, Kumar R, Kumar P and Mohan B 2017. Effect of phosphorus, sulphur and zinc on growth, yield and yield attributes of wheat (*Triticum aestivum*). *International Journal of Current Microbiology and Applied Sciences* **6**(8): 2581-2584.

Ye DL, Zhang YS, Alkaisi MM, Duan LS, Zhang MC and Li ZH 2016. Ethephon improved stalk strength associated with summer maize adaptations to environments differing in nitrogen availability in the North China Plain. *Journal of Agricultural Sciences* **154**: 960-977.

Zhang Y, Su S, Tabori M, Yu J, Chabot D and Baninasab B 2017. Effect of selected plant growth regulators on yield and stem height of spring wheat in Ontario. *Journal of Agricultural Sciences* **9**: 30-42.