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Effect of growth regulators on growth, phenological and biochemical traits of wheat [*Triticum aestivum* L.] under reduced irrigation situation

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Abstract
The present investigation entitled "Effect of growth regulators on growth, phenological and biochemical traits of wheat [*Triticum aestivum* L.] under reduced irrigation situation" was conducted in randomised block design with double dose of growth regulators with control wheat plants *viz.*, Control, GA_3 20 ppm, GA_3 40 ppm, Alar 100 ppm, Alar 200 ppm, ABA 25 ppm, ABA 50 ppm, SA 50 ppm, SA 100 ppm, Kinetin 5 ppm and Kinetin 10 ppm widely differing in their role in wheat variety (K1317) during two experimental years *i.e.*, 2017-18 and 2018-19, under reduced irrigation situation. Observations were recorded at different crop growth stages. Results revealed that almost all traits varied significantly due to tested growth regulators except initial plant population and days to heading during both experimentation years i.e., 2017-18 and 2018-19. Findings indicated that effect of growth regulators *viz.*, GA_3 40 ppm, Kinetin 10 ppm and Alar 200 ppm improved plant height and number of tillers per plant, while Kinetin 10 ppm was helped in higher fat content in wheat grains although, poor performance for most of studied parameters were recorded with control wheat plants as compare to other treatments under reduced irrigation situation.

Keywords: growth regulators, initial plant population, plant height, number of tillers, days to heading and fat content

Introduction

Wheat (*Triticum aestivum* L.) is one of the most essential crops worldwide (Yang *et al.*, 2018) [20]. The grains of wheat contain large amounts of carbohydrates in addition to proteins and some minerals and vitamins. Wheat is the world's most outstanding crop that excels all other cereals both in area and production, known as king of cereals and it is also one of the most nutritious cereals and its contribution to human diet puts it in the first rank of plants that feed the world (Costa *et al.*, 2013) [5]. India is the largest wheat producing country in the world after China. This could be achieved by introducing more productive varieties, improving the culture practices such as sowing wheat in the newly reclaimed area or application of some growth promoters during different growth stages.

Abiotic stresses generally cause reduction in the synthesis of plant hormones in plants and their degradation is also noticed in some cases. For example, it has been shown that drought stress is associated with greater abscisic acid concentration in most crop plants having a negative impact on gibberellins, indole acetic acid and cytokinin concentrations (Bano and Yasmeen, 2010) [2]. Water deficit conditions diminish leaf relative water content, resulting in a decline in nutrient uptake and wheat productivity (Khan *et al.*, 2018) [9].

Plant growth regulators (PGRs) are widely used in contemporary agriculture to promote plant growth, yield and grain quality. Both beneficial and adverse effects of PGRs on growth and development as well as plant metabolism have been addressed extensively (Ashraf *et al.*, 2011) [1]. PGRs significantly increased all physiological and yield characters (Meera and Poonam, 2010) [13] and they have potential to increase grain yield and may also alter grain protein levels of cereal crops especially wheat (Ma *et al.*, 1994) [12]. Hormones are one of the most significant factors in regulating plant growth, this hormonal regulation of plant growth and metabolism are extremely complicated and results from interaction between hormones (Lenoble *et al.*, 2004) [10]. Plant hormones such as gibberellic acids (Chunthaburee *et al.*, 2014) [4], abscisic acid (Wei *et al.*, 2017) [20], and salicylic acid (Dotto and Neumann Silva, 2017) [6] have been used to improve seed germination and seedling growth of different crop species such as rice, maize, sugarbeet, wheat and safflower. Gibberellins, (GAs) a group of diterpenoid plant hormones, have an important role in regulation of diverse developmental processes in plants such as seed germination, cell and organ elongation as well as flowering and have wide applications in modern agriculture (Taiz and Zeiger, 2010) [19]. Plant growth regulators, especially GA have important role in growth, development, yield and quality on formation (Ekamber and Kumar, 2007) [7]. ABA is known as an effective and major factor in regulating the translocation of photosynthates to the seeds or growing fruits (Bremer *et al*., 1995) [3]. But contradictory findings have been reported on the role of ABA in regulating the ageing process and retranslocation of photosynthates (Yang *et al*., 2002) [21]. The amount of salicylic acid (SA) in the leaves and reproductive organs of angiosperm plants has been found to be approximately 1mg g^{-1} fresh weight. In addition, it is known that SA has a regulatory role in a range of physiological processes, such as photosynthesis, transpiration, nutrient uptake, chlorophyll synthesis and plant development (Raskin I, 1992) [18]. SA was later recognized as an important signaling molecule that potentially influences plant tolerance to water stress because of its influence on the regulation of metabolic and physiological activities during the entire lifespan of the plant, affecting its growth parameters and bio-productivity (Popova *et al*., 1997) [17]. It has also been proved that SA decreases the plant's susceptibility to water deficit and that plants with adequate internal SA levels have better-hydrated tissues than those with SA deficiency (Pirasteh-Anosheh *et al*., 2012) [16]. The obvious increase in protein contents of grain as a result of kinetin application may be due to the fact kinetin enhances the absorption of nitrogenous compounds from the soil, as was suggested by Hegazy *et al*., (1972) [8].

Materials and Methods

Research experiment on entitled effect of growth regulators on growth, phenological and biochemical traits of wheat [*Triticum aestivum* L.] under reduced irrigation situation were carried out during *Rabi* season 2017-18 and 2018-19 in randomized block design with three replications at Students' Instructional Farm of C.S. Azad University of Agriculture and Technology, Kanpur (U.P.). The total rainfall was nil during crop growth periods during both year experimentation. The experiment carried out with foliar application of five growth regulators each with two concentration in ppm *viz*., GA_3 (20 and 40), Alar (100 and 200), ABA (25 and 50), SA (50 and 100), Kinetin (5 and 10) and Control, which were replicated two times, first at 30 days after sowing and second at anthesis with the help of sprayer. Growth Observations i.e., initial plant population, plant height (cm) and number of tillers $plant^{-1}$ were recorded at different growth stages, Phenological such as days to heading noted at the time of 75 per cent heading initiation and biochemical trait i.e., fat content in grains were estimated after harvest by Soxhlet extraction method.

Results and Discussion

Initial plant population

Data pertaining to initial plant population counted after complete germination of seed (Table 1), which revealed that it varied non-significantly. Among treatments, the number of initial plant population of wheat variety K1317 was varied in the range of 120 to 124 during both the years of study. Higher value of initial plant population was recorded with Alar 200 ppm (124) and S A 100 ppm (124) fallowed by GA_3 20 ppm (123) and the lower value was recorded with control (120) and GA_3 40 ppm (120) in 2017-18 while in 2018-19 the higher value of initial plant population was recorded with GA_3 20 ppm (124) and lower value with GA_3 40 ppm (120).

Plant height (cm)

Data regarding plant height was affected by various growth regulators (Table 1), which clearly show that plant height progressively increased with the age of plant. It is evident from the data that at 30 DAS, application of growth regulators were found effective but non-significantly increased plant height. Assuming the retardant treatments like Alar and ABA with different doses, plant height effectuate declining trend (1.5 to 4.5% decrease over control). At 60 DAS, plant height rise sharply as compare to 30 DAS. Significantly highest value of plant height (64.63 and 65.75) was recorded with the effect of GA_3 40 ppm being at par with Kinetin 10 ppm (63.73 and 65.03), respectively during both the years. On contrary of this significantly lowest value was recorded with ABA 50 ppm (56.03 and 56.41) followed by ABA 25 ppm (56.13 and 56.84) in first and second year. Maximum plant height was found at 90 DAS with the treatment of GA_3 40 ppm (94.15 and 94.15) being at par with Kinetin 10 ppm (93.27 and 94.05), GA_3 20 ppm (92.13 and 92.87) and Kinetin 5 ppm (91.90 and 92.43), respectively during first and second year of experiment. Whereas, minimum value of this parameter was noted with the treatment of ABA 50 ppm (87.63 and 88.15) followed by ABA 25 ppm (88.05 and 88.34), respectively during first and second year under reduced irrigation situation. Similar, observations were recorded earlier (Pavlista, A.D. and Santra, D.K. 2013) [15].

Table 1: Effect of growth regulators on initial plant population and plant height (cm) of wheat at different growth stages

Treatments	Initial plant population		Plant height (cm)					
			30 DAS		60 DAS		90 DAS	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Control	120	121	25.05	25.07	58.47	58.63	90.17	90.52
GA_3 20 ppm	123	124	25.91	25.92	62.05	63.00	92.13	92.87
GA_3 40 ppm	120	120	26.13	26.14	64.63	65.75	94.15	95.11
Alar 100 ppm	122	123	24.97	24.97	57.60	58.47	88.83	89.48
Alar 200 ppm	124	122	24.84	24.85	56.26	57.11	88.55	89.76
ABA 25 ppm	121	123	24.77	24.78	56.13	56.84	88.05	88.34
ABA 50 ppm	122	121	24.65	24.65	56.03	56.41	87.63	88.15
S A 50 ppm	123	122	25.30	25.31	59.43	60.12	90.25	90.92
S A 100 ppm	124	123	25.80	25.82	60.20	60.85	90.48	91.07
Kinetin 5 ppm	121	122	25.83	25.85	61.60	62.47	91.90	92.43
Kinetin 10 ppm	122	123	26.00	26.04	63.73	65.03	93.27	94.05
S.E. (d)	1.49	1.70	0.61	0.68	1.20	1.30	1.55	1.69
C.D at 5%	NS	NS	NS	NS	2.51	2.72	3.23	3.54

Number of tillers plant^{-1}

The findings on number of tillers plant^{-1} were recorded at 30, 60, 90 DAS and at maturity stage are furnished in (Table 2) revealed that number of tillers plant^{-1} at 30 DAS, did not show significant with the different concentration of growth regulators applied. At 30 DAS, maximum number of tillers plant^{-1} was found treated with GA_3 40 ppm (2.97) followed by Kinetin 10 ppm (2.90) in first year while, it was maximum in second year with GA_3 40 ppm (2.99) followed by Alar 200 ppm (2.95). Minimum value of it was found with control (2.53 and 2.54) during both years of study. The effect of foliar application of GA_3 40 ppm (6.23 and 6.27) was more pronounced being at par with Alar 200 ppm (6.00 and 6.02), Kinetin 10 ppm (5.84 and 5.88), S A 100 ppm (5.72 and 5.76) and Kinetin 5 ppm (5.57 and 5.61) significantly increased the number of tillers plant^{-1} while, minimum tillers plant^{-1} was recorded with control (4.81 and 4.83) followed by ABA 50 ppm (4.99 and 5.00) during 2017-18 and 2018-19 at 60 days after sowing. During 90 DAS, highest significant value on number of tillers plant^{-1} of wheat crop was observed by again the treatment of GA_3 40 ppm (6.40 and 6.42) which was being at par with Alar 200 ppm (6.27 and 6.29), Kinetin 10 ppm (6.17 and 6.20), S A 100 ppm (5.97 and 5.99), Kinetin 5 ppm (5.83 and 5.85) and GA_3 20 ppm (5.61 and 5.62), respectively during both years. However, lowest value was noted with the control (5.05 and 5.06). Same trend was observed during maturity stage of wheat crop which influenced by all growth regulators on number of tillers plant^{-1} show significant and the maximum value was found with GA_3 40 ppm (6.35 and 6.36) being at par with Alar 200 ppm (6.15 and 6.16), Kinetin 10 ppm (6.13 and 6.15), S A 100 ppm (5.83 and 5.84), Kinetin 5 ppm (5.76 and 5.77) and GA_3 20 ppm (5.55). The minimum tillers were recorded with control (4.99 and 5.00) and both concentration of rest treatments had number of tillers plant^{-1}, range in between 5.08 to 5.36 and 5.06 to 5.55 among both years of experimentation. External application of abscisic acid (ABA) slightly slows the growth rate of rice tiller buds reported by (Liu *et al.,* 2011) [11].

Table 2: Effect of growth regulators on number of tillers plant^{-1} of wheat at different growth stages

Treatments	Number of tillers plant^{-1}							
	30 DAS		60 DAS		90 DAS		Maturity	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Control	2.53	2.54	4.81	4.83	5.05	5.06	4.99	5.00
GA_3 20 ppm	2.80	2.83	5.35	5.38	5.61	5.62	5.55	5.55
GA_3 40 ppm	2.97	2.99	6.23	6.27	6.40	6.42	6.35	6.36
Alar 100 ppm	2.75	2.76	5.21	5.22	5.42	5.43	5.36	5.37
Alar 200 ppm	2.89	2.95	6.00	6.02	6.27	6.29	6.15	6.16
ABA 25 ppm	2.68	2.70	5.05	5.08	5.20	5.21	5.18	5.19
ABA 50 ppm	2.62	2.65	4.99	5.00	5.13	5.13	5.08	5.06
S A 50 ppm	2.71	2.74	5.18	5.20	5.35	5.36	5.21	5.22
S A 100 ppm	2.86	2.89	5.72	5.76	5.97	5.99	5.83	5.84
Kinetin 5 ppm	2.83	2.86	5.57	5.61	5.83	5.85	5.76	5.77
Kinetin 10 ppm	2.90	2.93	5.84	5.88	6.17	6.20	6.13	6.15
S.E. (d)	0.26	0.27	0.36	0.37	0.41	0.44	0.38	0.40
C.D at 5%	NS	NS	0.75	0.78	0.85	0.92	0.80	0.85

Days to heading

Data regarding days to heading are presented in (Table 3) revealed that it differed non-significantly during 2017-18 and 2018-19. Effect of growth regulator Alar 200 ppm (78.10 and 78.72) delay maximum but non-significant days to heading followed by Kinetin 10 ppm (77.80 and 78.46) and Kinetin 5 ppm (77.63 and 77.82) while, the response of growth regulator GA_3 40 ppm (76.00 and 76.18) after that GA_3 20 ppm (76.18 and 76.35) caused early heading as compare to control. The results were in consonance with the works of Mustafa *et al.* (2016) [14] and Zachrias *et al*. (2010) [20]

Fat content (%)

The data pertaining to fat content showed significant differences among all treatments during both the years of investigation are presented in (Table 3). It was clearly revealed that fat content in wheat grains significantly maximum estimated with effect of Kinetin 10 ppm (1.51) being at par with Kinetin 5 ppm (1.48 and 1.49) and GA_3 40 ppm (1.46 and 1.47) and minimum value of fat content was observed with control (1.26 and 1.25) during 2017-18 and 2018-19, respectively. Whereas, remaining of the treatments had fat content in grains of wheat variety K1317 range in between 1.28 to 1.42 in 2017-18 and 1.27 to 1.42 in second year of the experiment under reduced irrigation situation.

Table 3: Effect of growth regulators on days to heading and fat content of wheat grains

Treatments	Days to heading		Fat content (%)	
	2017-18	2018-19	2017-18	2018-19
Control	76.27	76.58	1.26	1.25
GA_3 20 ppm	76.18	76.35	1.42	1.42
GA_3 40 ppm	76.00	76.18	1.46	1.47
Alar 100 ppm	77.30	77.65	1.30	1.31
Alar 200 ppm	78.10	78.72	1.28	1.27
ABA 25 ppm	77.21	77.64	1.31	1.32
ABA 50 ppm	76.41	76.73	1.37	1.36
S A 50 ppm	76.85	77.11	1.35	1.34
S A 100 ppm	77.13	77.47	1.39	1.40
Kinetin 5 ppm	77.63	77.82	1.48	1.49
Kinetin 10 ppm	77.80	78.46	1.51	1.50
S.E. (d)	0.67	0.97	0.03	0.03
C.D at 5%	NS	NS	0.08	0.07

Conclusion

Based on the present study it is concluded that all the studied traits have direct or indirect impact on yield which influencing by growth regulators under restricted irrigation condition.

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