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Effect of NAA, GA_3 and ascorbic acid on growth and Morpho-physiological parameters of wheat cv. GJW-463

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Abstract
A field experiment was conducted during the *rabi* 2017-2018 at Wheat Research Station, Junagadh Agricultural University, Junagadh to study the effects of NAA (Naphthalene Acetic Acid), GA_3 and ascorbic acid on growth and morpho-physiological of wheat cv. GJW-463. The investigation was carried out in RBD with three replications and foliar application of different concentration of NAA, GA_3 and ascorbic acid such as NAA (25,50, 75 ppm), GA_3 (150, 250, 450 ppm) at 30 & 45 DAS and ascorbic acid (200, 300, 400 ppm) at 45 & 60 DAS. The experiment results revealed that foliar application of NAA, GA_3 and ascorbic acid increased the plant height and flag leaf area was more in GA_3 @ 150 ppm treated plants. Among different treatments, significantly higher LAI, CGR (g m^{-2} day^{-1}), LAD (m^2 m^{-2} day^{-1}), NAR (mg cm^2 day^{-1}) and seed yield (kg ha^{-1}) were observed in GA_3@ 150 ppm treated plants as compared to control.

Keywords: AsA, CGR, GA_3, LAD, LAI, NAR

Abbreviations
AsA: Ascorbic Acid, CGR: Crop Growth Rate, GA_3: Gibberellic Acid, LAD: Leaf Area Duration, LAI: Leaf Area Index, NAR: Net Assimilation Rate

Introduction
Wheat (*Triticum aestivum* L.) is one of the most important cereal crop belongs to *Poaceae* family and staple food crop of the world. Wheat is also called as "King of Cereals". Wheat is a grass mainly cultivated for its seed. It is native of South West Asia (Turkey). Wheat possess 2n=42 chromosomes with self-pollination as a mode of pollination. Wheat is one of the second most significant cereals in India following rice, contributing substantially to the national food security by providing more than 50% of the calories to the people who mainly depend on it. In the world, wheat has total area of 221.12 million ha, production 697.8 million tons and 3.16 tons/ha productivity. Wheat has total area of 29.72 million ha, production 98.61 million tons and 3.66 tons/ha productivity in India. The highest productivity of wheat is recorded in Punjab, whereas Gujarat stands 6th rank with productivity of 3.07 t/ha in India.

Agricultural research, till now, has been primarily concerned with increasing crops yield by use of fertilizers, pesticides, irrigation, better crop management coupled with variety development and genetic improvement. Now a day due to the increase in fertilizer, pesticide, herbicides uses they become effect on the soil, plant productivity, fertility and the environment. It has been the endeavour of crop physiology to influence crop growth and production by the exogenous application of the growth regulators.

Several growth regulators differ in regulating plant growth. NAA, a synthetic form of auxin, plays key roles in cell elongation, cell division, vascular tissue differentiation, root initiation. GA_3 stimulated rapid cell division and elongation in plant stems and shoots. Ascorbic acid (AsA) influences mitosis and cell growth in plants (Noctor and Foyer, 1998; Smirnoff and Wheeler, 2000) [11, 16], affects phytohormone-mediated signaling processes during the transition from the vegetative to the reproductive phase as well as the final stage of development and senescence. Therefore, the present research work was conducted to investigate the effect of foliar application of NAA, GA_3 and

ascorbic acid on growth and morpho-physiological performance of wheat.

Materials and Methods

The present investigation was conducted at Wheat Research Station, JAU, Junagadh during *rabi* season of 2017-18. The experiment constituted of 10 treatments was laid out in RBD design with three replications. Solutions of NAA (25, 50, 75 ppm), GA_3(150, 250, 450 ppm) were prepared and sprayed on the foliage of plants at 30 & 45 DAS with the help of hand sprayer as per treatment and AsA (200, 300, 400 ppm) at 45 & 60 DAS while distilled water was sprayed in untreated control. The crop was fertilized with a uniform dose of nitrogen, phosphorus and potash at the rate of 120 kg, 60 kg and 60 kg ha^{-1}, respectively.

Growth and morpho-physiological parameters

Plant height, leaf area index (LAI), flag leaf area (FLA), crop growth rate (CGR), leaf area duration (LAD) and net assimilation rate (NAR) were counted from the selected five plants in each treatment from all replications at 45, 60, 75 and 90 DAS.

Plant height (cm): Plant height was measured from ground level to the tip of main axis was counted from the selected five plants in each treatment from all replications during 45, 60, 75 and 90 DAS.

Leaf area index: The leaf area index was calculated by dividing the total leaf area with the corresponding ground area as suggested by Watson (1952) [17] at 45, 60, 75 and 90 DAS.

$$\text{Leaf area index} = \frac{\text{Leaf Area}}{\text{Ground Area}}$$

Flag leaf area: Flag leaf area was recorded by leaf area meter of selected five plants in each treatment from all replications at 45, 60, 75 and 90 DAS expressed in cm^2.

Crop growth rate (CGR): By using the total dry matter of the plant, CGR was calculated by using the formula given by Watson (1952) [17] at 45, 60, 75 and 90 DAS and expressed in g m^{-2} day^{-1}.

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \text{ X } \frac{1}{\text{A}}$$

Where,
W_1 = Dry weight of the plant (g) at time t_1
W_2 = Dry weight of the plant (g) at time t_2
$t_2 - t_1$ = Time interval in days
A = Land area (m^2)

Leaf area duration (LAD): It is ability of the plant to maintain the green leaves per unit area of the land over a period of time. Leaf area duration (LAD) is correlated with dry matter yield and LAI (Power *et al.* 1967) [13]. LAD was taken into account, both the duration and extent of photosynthetic tissue of the crop canopy at 45, 60, 75, 90 DAS. The LAD is expressed in day.

$$LAD = \frac{L_1 + L_2}{T_2 - T_1} \text{ X } 2$$

Where,
L_1 = LAI at the first stage
L_2 = LAI at the second stage
$t_2 - t_1$ = Time interval in day

Net assimilation rate (NAR): Net assimilation rate is the rate of dry weight increase per unit leaf area per unit time (Watson, 1952) [17]. It was calculated by following the formula and expressed as mg cm^{-2} day^{-1} at 45, 60, 75 & 90 DAS from each treatment and replication.

$$NAR = \frac{W_2 - W_1}{T_2 - T_1} X \frac{LogeA_2 - LogeA_1}{A_2 - A_1}$$

Where,
W_1 and W_2 = Dry weight of whole plant at time t_1 and t_2 respectively.
A_1 and A_2 = Leaf weights or leaf area at t_1 and t_2 respectively
$t_2 - t_1$ = Time interval in days

Seed yield (kg/ha): After harvesting total seed yield per net plot was recorded in kilogram from each treatment and converted in hectare from all replications.

Statistical analysis: The data were analyzed by method of analysis of variance obtained by Panse and Sukhatme (1995) [12]. Significance was tested by "F" value at 5 percent level of probability. Critical differences were worked out for the effects which are significant.

Results and Discussion

Plant height (cm): The data regarding plant height are presented in Table 1 showed that the plant height influenced significantly with the different concentrations of NAA, GA_3 and ascorbic acid treatments during 45-60, 60-75, and 75-90 DAS. In compared with control significantly the highest mean plant height observed in treatment T_4 (109.89 cm) and it was statistically at par with treatments T_7 (99.14 cm) and T_3 (99.01 cm), while control (87.43 cm) recorded minimum mean plant height. Over all experimental results are presented that data of plant height continually increased with increasing crop age up to harvest. The increase mean plant height may be due to internode elongation. The application of growth promotive substances increased the plant height and such effect was due to increased photosynthetic activity, enhancement in the mobilization of photosynthates and change in the membrane permeability that lead yield improvement which was similarly accordance with Sajo and Kabura, (1998) [15] in wheat and Niknejhad and Pirdashti (2012) [12] in rice.

Leaf area index: Scrutiny of data in Table 1 revealed that the leaf area index influenced significantly with the NAA, GA_3 and ascorbic acid treatments during 45-60, 60-75, and 75-90 DAS. In compared with control significantly the highest mean LAI observed in treatment T_4 (4.71) which was at par with all the treatments except T_8 (4.11). The lowest mean LAI was recorded in control (3.60). In the present study, the LAI was found a typical sigmoidal pattern with an initial slow increased in leaf area followed by a steep rise. The LAI increases with increases growth stage of plant 45 DAS and up to 90 DAS. Leaf area fairly gives a good idea of the photosynthetic capacity of the plant. Ram *et al.* (2013) [14] reported similar increment was observed in plant height, no. of tillers, leaf area and leaf area index of wheat irrigated with SW (sewage water) + GA_3 compared to SW alone in both the concentrations and control.

Flag leaf area: A perusal of data in Table 1 revealed that different growth regulator treatments showed their significant effect on flag leaf area at 45-60, 60-75, and 75-90 DAS. Over

all experimental result showed that flag leaf area was found higher in treatment T_4 (28.44 cm^2) at 90 DAS, which was at par with treatments T_7 (27.06 cm^2), T_3 (26.97 cm^2), T_2 (26.51 cm^2) and T_9 (26.41 cm^2). The lowest flag leaf area was recorded in control (22.97 cm^2). Flag leaf has important and significant vital role to contribution of spike yield especially at early complete emergence stage of flag leaf in plant. similarly results were obtained by Katta *et al.* (2012) [7] reported that application of GA_3 at the rate of 300 g ha^{-1} at first day of heading increased the flag leaf area inside seed production plot in rice and (Alhaidary and Ahmad, 2017) [1] in wheat.

Table 1: Effect of NAA, GA3, ascorbic acid on plant height, leaf area index (LAI) and flag leaf area of wheat cv. GJW-463.

Treatments		Plant height (cm)				Leaf area index (LAI)				Flag leaf area (cm^2)			
		45-60 DAS	60-75 DAS	75-90 DAS	Mean	45-60 DAS	60-75 DAS	75-90 DAS	Mean	45-60 DAS	60-75 DAS	75-90 DAS	Mean
T1	NAA @ 25 ppm	47.21	81.28	92.34	94.91	78.94	3.69	3.93	4.05	18.87	21.45	23.56	24.79
T2	NAA @ 50 ppm	49.40	84.41	96.10	98.04	80.99	3.85	4.06	4.33	20.17	23.17	24.53	26.51
T3	NAA @ 75 ppm	50.73	84.67	96.39	99.01	82.70	3.87	4.07	4.40	20.24	23.19	25.19	26.97
T4	GA3 @ 150 ppm	52.35	85.35	102.29	109.89	87.47	4.02	4.16	4.58	21.96	24.26	26.45	28.44
T5	GA3 @ 250 ppm	47.91	83.14	93.87	95.01	79.98	3.75	4.01	4.10	20.14	22.20	23.61	25.05
T6	GA3 @ 450 ppm	45.40	80.17	86.58	91.95	76.03	3.57	3.91	4.06	18.61	21.34	20.96	24.65
T7	AsA @ 200 ppm	43.35	84.76	96.40	99.14	80.91	3.49	4.13	4.44	17.62	24.16	26.00	27.06
T8	AsA @ 300 ppm	44.63	77.36	86.37	90.18	74.64	3.47	3.68	4.02	17.51	20.34	21.41	23.15
T9	AsA @ 400 ppm	42.06	83.68	94.09	97.89	79.43	3.52	4.03	4.21	17.54	22.31	24.13	26.41
T10	Control	43.82	66.24	81.60	87.43	69.77	3.48	3.49	3.62	17.42	19.43	21.71	22.97
S.Em.±		1.50	2.72	3.43	3.79	2.75	0.10	0.13	0.15	0.91	0.90	1.03	1.13
C.D. at 5%		4.46	8.09	10.20	11.27	8.18	0.32	0.39	0.45	2.70	2.69	3.07	3.34
C.V. %		5.40	5.81	6.42	6.82	6.03	5.11	5.81	6.26	8.27	7.06	7.54	7.62

Crop growth rate (CGR, gm^{-2} day^{-1}): The data summarized in Table 2 showed that the CGR influenced significantly with the different concentration of NAA, GA_3 and ascorbic acid treatments during 45-60 DAS, 60-75 DAS and 75-90 DAS. The CGR was found significantly higher in treatment T_4 (24.27gm^{-2} day^{-1}) during 75-90 DAS and it remained at par with treatments T_7 (24.25 $gm^{-2}day^{-1}$), T_3 (23.62 $gm^{-2}day^{-1}$) and T_2 (23.56 g $m^{-2}day^{-1}$), while control (16.70 $gm^{-2}day^{-1}$) recorded minimum CGR. In present study indicated that higher CGR due to GA_3 application may have induced higher production of cytokinin than control. Growth rate of wheat has significant relation with GA_3 application because most plants were healthy and vigorous which may help the plants to absorb water and light more efficiently that may have resulted higher CGR. This finding closely related to Islam *et al.* (2014) [5] and Khudhair *et al.*, (2017) [8] in wheat.

Table 2: Effect of NAA, GA3, ascorbic acid on crop growth rate, leaf area duration, net assimilation rate and seed yield of wheat cv. GJW-463.

Treatments		Crop growth rate (CGR, g m^{-2} day^{-1})				LAD (m^2 m^{-2} day^{-1})				NAR (mg cm^{-2} day^{-1})				Seed yield at harvest (kg ha^{-1})
		45-60 DAS	60-75 DAS	75-90 DAS	Mean	45-60 DAS	60-75 DAS	75-90 DAS	Mean	45-60 DAS	60-75 DAS	75-90 DAS	Mean	
T1	NAA @ 25 ppm	22.17	9.16	18.63	19.23	11.28	11.98	12.83	12.03	0.175	0.176	0.184	0.178	4583.33
T2	NAA @ 50 ppm	23.60	10.07	21.21	23.56	11.63	12.53	13.40	12.52	0.180	0.178	0.191	0.183	5000.00
T3	NAA @ 75 ppm	23.90	10.78	21.58	23.62	11.86	12.90	13.51	12.76	0.185	0.182	0.197	0.188	5375.00
T4	GA3 @ 150 ppm	25.28	12.73	21.96	24.27	12.11	12.93	13.61	12.88	0.201	0.196	0.223	0.207	5850.00
T5	GA3 @ 250 ppm	22.75	9.49	18.73	20.87	11.28	12.01	13.14	12.14	0.176	0.176	0.187	0.180	4666.67
T6	GA3 @ 450 ppm	21.39	8.63	17.43	18.24	10.66	11.93	12.54	11.71	0.175	0.171	0.182	0.176	4479.16
T7	AsA @ 200 ppm	23.71	10.85	21.92	24.25	11.99	12.91	13.53	12.81	0.194	0.189	0.210	0.197	5593.75
T8	AsA @ 300 ppm	20.60	8.56	16.89	17.65	10.47	11.74	12.01	11.41	0.174	0.169	0.181	0.175	4395.83
T9	AsA @ 400 ppm	22.60	9.70	18.73	21.23	11.33	12.52	13.31	12.39	0.178	0.178	0.189	0.182	4750.00
T10	Control	20.38	8.25	15.31	16.70	10.35	11.27	11.57	11.06	0.171	0.167	0.175	0.171	4187.53
S.Em.±		0.94	0.330	0.591	0.859	0.859	0.356	0.391	0.390	0.0061	0.0053	0.0061	0.0064	262.79
C.D. at 5%		2.81	0.982	1.757	2.552	2.552	1.057	1.162	1.158	0.0180	0.0156	0.0181	0.0189	780.79
C.V. %		7.23	5.83	5.32	8.923	8.923	5.02	5.24	5.54	5.82	5.11	5.47	6.0020	9.31

Leaf area duration (LAD, m^2 m^{-2} day^{-1}): A perusal of data in Table 2 reported that NAA, GA_3 and ascorbic acid treatments showed their significant effect on leaf area duration (LAD) between 45-60, 60-75 and 75-90 DAS. Significantly the higher LAD was observed in treatment T_4 (13.61 m^2 m^{-2} day^{-1}) during 75-90 DAS which was at par with all the treatments except T_6(12.54 m^2 m^{-2} day^{-1}) and T_8 (12.01 m^2 m^{-2} day^{-1}). The lowest LAD was recorded in control (11.57 m^2 m^{-2} day^{-1}). Leaf area duration is the long-term relationship of information found from the leaf area index, where the volume of ground covered in relation to upper leaf surface area is measured against time. Similarly, Mishra and Gaur (1985) [9] reported that leaf area duration significantly increased when apply GA_3 alone and combination with kinetin compared to control in barley.

Net assimilation rate (NAR, mg $cm^{-2}day^{-1}$): Examination of data Table 2 indicated that application of NAA, GA_3 and ascorbic acid had significant effect on net assimilation rate (NAR) between 45-60, 60-75 and 75-90 DAS. Significantly the higher NAR was observed in treatment T_4 (0.223 mg cm^{-2} day^{-1}) during 75-90 DAS which was at par with treatments T_7 (0.210 mg cm^{-2} day^{-1}) and T_3 (0.197 mg cm^{-2} day^{-1}). The lowest NAR was recorded in control (0.175 mg cm^{-2} day^{-1}). Katayama and Akita (1989) [6] reported that increased NAR due to increased sink activity by the exogenous application of GA_3 is one of the major factors for promoting initial growth of rice by GA_3 treatment. Islam *et al.* (2014) [5] studied on

growth and yield performance of wheat to gibberellic acid concentrations and who was reported that maximum NAR found from treatment compare to control.

Seed yield (kg ha^{-1}): The data regarding of seed yield are presented in Table 2 which was indicated that higher seed yield per hectare 5850 kg ha^{-1} was obtained with the treatment (T_4) which was at par with treatments T_7 (5593.75 kg ha^{-1}) and T_3 (5375.00 kg ha^{-1}). The lower seed yield was recorded in control 4187.53 kg ha^{-1}. Zheng and Flower (2011) [18] showed that appropriate plant growth regulators, likes GA usage can improve photosynthesis capacity and seed number increasing in wheat. Similar result was obtained by Goufo and Tang (2011) [4] in rice. Eskandari and Shokuhfar (2015) [3] studied on effect of gibberellic acid on wheat and reported that effect of different GA concentration, cultivar and their interaction on seed yield was significant.

Conclusion

The observations made in these investigations indicate possibility of a significant change in morphological and growth behavior pattern of wheat plant through foliar application of NAA, GA_3 and ascorbic acid. On the basis of experiment, it is concluded that, application of GA_3@ 150 ppm had significant influence on growth and morpho-physiological characters of wheat especially an increased plant height, flag leaf area, leaf area index, LAD, CGR, NAR and thereafter increased yield of wheat.

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