International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(3): 1317-1321

Received: 10-03-2020
Accepted: 12-04-2020

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Effect of plant growth regulators on biochemical analysis of onion (*Allium cepa*)

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DOI: https://doi.org/10.22271/chemi.2020.v8.i3r.9381

Abstract
A field experiment was carried out during Rabi 2018 and 2019 at RHRS, Navsari Agricultural University, Navsari, Gujarat to study the effect of different plant growth regulators like GA_3 and NAA on biochemical parameters of onion. The treatment T_1 (GA_3 25 mg l^{-1}) recorded highest chlorophyll content of leaves 45 DATP (1.06 mg 100 g^{-1}), 60 DATP (2.64 mg 100 g^{-1}), 90 DATP (2.32 mg 100 g^{-1}), ascorbic acid (10.45 mg 100 g^{-1}), phenols (61.77 mg 100 g^{-1}) and proteins (1072.54 mg 100 g^{-1}) and found significant. The moisture content (83.98%) under T_6 (NAA 75 mg l^{-1}) were found significant.

Keywords: Plant growth regulators, GA_3, NAA, onion *etc.*

Introduction
India is the world's second largest producer of vegetables (187.47 million tonnes) next only to China (Anonymous, 2019). Onion (*Allium cepa* L.) is an important and indispensable item in every kitchen as condiment cum vegetable in India. It is one of the important underground bulbous vegetable crops of Alliaceae family and is said to be native of Central Asia and Mediterranean region (Mc Collum, 1976). Plant growth regulators are organic compounds other than nutrients which in small amount promotes / inhibit or otherwise modify any physiological response in plant (Purohit, 2007) [9]. Plant bioregulators called as magic chemicals are new generation agrochemicals, when added in small quantity, modify the natural growth regulatory systems right from seed germination to senescence in several vegetable crops and also regulate and modify various physiological processes within the plant and they help to increase the yield (Weaver, 1972) [12].

Materials and methods
The field experiment was carried out at the vegetable research scheme, Regional Horticultural Research Station of the Navsari Agricultural University, Navsari, Gujarat, India during *Rabi* 2018 and 2019 on cv. Gujarat Junagadh Red Onion 11 to investigate the response of plant bioregulators on growth parameters and plant growth analysis of onion. The experiment was conducted in Randomized Block Design (RBD) with three replications, which included 12 treatments namely, T_1: GA_3 25 mg l^{-1}, T_2: GA_3 50 mg l^{-1}, T_3: GA_3 75 mg l^{-1}, T_4: NAA 25 mg l^{-1}, T_5: NAA 50 mg l^{-1}, T_6: NAA 75 mg l^{-1}, T_7: GA_3 25 mg l^{-1} + NAA 25 mg l^{-1}, T_8: GA_3 25 mg l^{-1} + NAA 50 mg l^{-1}, T_9: GA_3 25 mg l^{-1} + NAA 75 mg l^{-1}, T_{10}: GA_3 50 mg l^{-1} + NAA 50 mg l^{-1}, T_{11}: GA_3 75 mg l^{-1} + NAA 75 mg l^{-1} and T_{12}: Control. The foliar sprays were made at 30 days after transplanting during morning hours to avoid the dehydration effect. For recording different observations, ten plants of onion from each net plot area were selected randomly and tagged with labels.

Results
Proteins (mg 100 g^{-1})
Results of proteins in onion bulb under different treatments showed significant in pooled analysis. The maximum protein content (1072.54 mg) observed with T_1 (GA_3 25 mg l^{-1}) followed by the treatment T_{10} (GA_3 50 mg l^{-1} + NAA 50 mg l^{-1}). Whereas, GA_3 75 mg l^{-1} + NAA 75 mg l^{-1} (T_{11}) recorded minimum protein content (866.82 mg). The interaction of year ×

treatment was found non-significant.

Phenols (mg 100 g^{-1})
The results of percent total phenols under different treatments showed significant in pooled analysis. The maximum phenol content (61.77 mg) observed with the treatment T_1 (GA_3 25 mg l^{-1}) which was significantly at par with T_{12}. The minimum phenol content (51.53 mg) observed with the treatment T_3. The interaction of year × treatment was found non-significant.

Chlorophyll content of leaves (mg 100g^{-1})
The results of chlorophyll content under different treatments found significant. In pooled analysis, the maximum chlorophyll content (1.06 mg; 2.64 mg and 2.32 mg) at 45, 60 and 90 DATP respectively was recorded with the treatment T_1 (GA_3 25 mg l^{-1}). The minimum chlorophyll content (0.82 mg) was recorded with T_{12} (Control) at 45 DATP whereas, chlorophyll content (2.33 mg and 2.07 mg) at 60 and 90 DATP respectively, was observed with the treatment T_3 (GA_3 75 mg l^{-1}).

Reducing sugar (%)
During the first season, the maximum percentage of reducing sugars (5.21%) observed with T_4 (NAA 25 mg l^{-1}) which was significantly at par with the treatments T_5, T_9, T_6 and T_3. Whereas, the minimum reducing sugars (3.67%) was registered with control (T_{12}). During the second season, the treatment GA_3 75 mg l^{-1} (T_3) was recorded maximum reducing sugars percentage (6.62%). Whereas, T_4 (NAA 25 mg l^{-1}) recorded minimum reducing sugars percentage (4.15%). In pooled analysis, the results of reducing sugars under different treatments found non-significant.

Total sugar (%)
During the first season, the maximum total sugar (6.94%) was found with the treatment T_{10} (GA_3 50 mg l^{-1}+ NAA 50 mg l^{-1}) which was significantly at par with the treatment T_8. As well as, the minimum percent of total sugars (5.06%) was found with the treatment control (T_{12}). During the second season, application of NAA 75 mg l^{-1} (T_6) recorded maximum total sugar (8.65%) which was significantly at par with the treatment T_9. Whereas, GA_3 25 mg l^{-1} (T_1) recorded minimum total sugars (5.73%). Looking to the mean of pooled analysis, results of total sugars under different treatments was non-significant.

Non- reducing sugar (%)
During the first season, maximum non-reducing sugars (2.82%) found with the treatment T_{10} (GA_3 50 mg l^{-1} + NAA 50 mg l^{-1}) which was superior over other treatments followed by T_8. Whereas, the minimum non-reducing sugars (0.59%) was found with the treatment T_4 (NAA 25 mg l^{-1}). The significantly maximum non-reducing sugars (4.76%) was observed with the treatment T_6 (NAA 75 mg l^{-1}) followed by T_9 during the second season. Whereas, the minimum non-reducing sugars (0.73%) was recorded with the treatment T_3 (GA_3 75 mg l^{-1}). The results of percent non-reducing sugars under different treatments showed non-significant in pooled analysis. The interaction of year × treatment was found non-significant.

TSS (%)
In pooled analysis, the results of TSS under different treatments showed non-significant. The interaction of year × treatment was found significant.

Moisture content (%)
Looking to the mean of pooled analysis, the maximum moisture content (83.98%) was obtained with T_6 (NAA 75 mg l^{-1}) which was significantly at par with the treatments T_5, T_8, T_{11}, T1 and T_{10}. The minimum moisture content (78.81%) was noted in control (T_{12}). The interaction of year × treatment was found non-significant.

Ascorbic acid content (mg 100 g^{-1})
The results of ascorbic acid under different treatments showed significant in pooled analysis. The maximum ascorbic acid content (10.45 mg) was observed with the treatment T_1 (GA_3 25 mg l^{-1}) which was significantly superior followed by T_{10}. The minimum ascorbic acid content (8.16 mg) was observed with the treatment control (T_{12}). The interaction of year × treatment was found non-significant.

Bulb pH
The significantly highest bulb pH (4.78) was found with the application of GA_3 75 mg l^{-1} + NAA 75 mg l^{-1} (T_{11}) which was significantly at par with the treatments T_3, T_{12}, T_6, T_9, T_8, T_5, T_{10}, T_2 and T_4 in first season. Whereas the lowest bulb pH (4.48) was obtained in T_1 (GA_3 75 mg l^{-1}). During the second season, the maximum bulb pH (4.77) was observed with T_6 (NAA 75 mg l^{-1}) which was significantly at par with the other treatments T_5, T_3, T_{11}, T_{10}, T_7, T_1, T_2 and T_4. The minimum bulb pH (4.38) was observed in control (T_{12}). The results of bulb pH under different treatments varied from 4.55 to 4.76 but it was non-significant. The interaction of year × treatment was found significant

Discussion
Chlorophyll-a and Chlorophyll-b were increased with GA_3 treatments in *Andrographis paniculata* (Gomatinayagam *et al.,* 2009). The results indicated that there was increase in chlorophyll content due to foliar application of gibberellic acid (GA_3) induces enhancement of ultra structural morphogenesis of plastids, which coupled with retention of chlorophyll, delay plant senescence (Arteca, 1996; Ouzounidu and Ilias, 2005; Shah *et al.,* 2007; Ouzounidu *et al*., 2011) [1, 6, 10]. This increase undoubtedly might have helped to improve the photosynthetic efficiency. The application of growth regulators may prove beneficial for improvement of growth and productivity of economically important vegetable crop onion. The plants under the influence of GA_3 was found with increased soluble carbohydrates, ascorbic acid content in tomato. Growth regulators improve the quality parameters of the onion bulbs due to enhanced physiological activity. The increase in TSS may be accounted due to the hydrolysis of polysaccharides. Conversion of organic acids in to soluble sugars and enhanced solubilisation of insoluble starch and pectin present in the cell wall and middle lamella. The increase in TSS content due to growth regulators found from the results of several workers (Tiwari *et al*., 2003; and Patel *et al.,* 2010) [11, 8] and Govind *et al*. 2015 [4] in garlic. The production of ascorbic acid content seems to be enhanced under GA_3. The increase in ascorbic acid content may be due to vitamin can be synthesized in plant by the process involves the conversion of hexose sugar mainly glucose and galactose into ascorbic acid. The results are in conformity with Ouzounidou *et al.* (2011) [5] in onion, Chaudhary *et al.* (2006) [2] and Ouzounidu *et al.* (2010) [7] in chilli and pepper. The moisture content showed significant results with NAA. Similar results with Govind *et al.* (2015) [4] in garlic.

Acknowledgements
I wish to express my sincere gratitude to Dr. S.N. Saravaiya, Associate Professor for providing an opportunity to do my project work in RHRS, Navsari Agricultural University, Gujarat during the year 2018 - 2019.

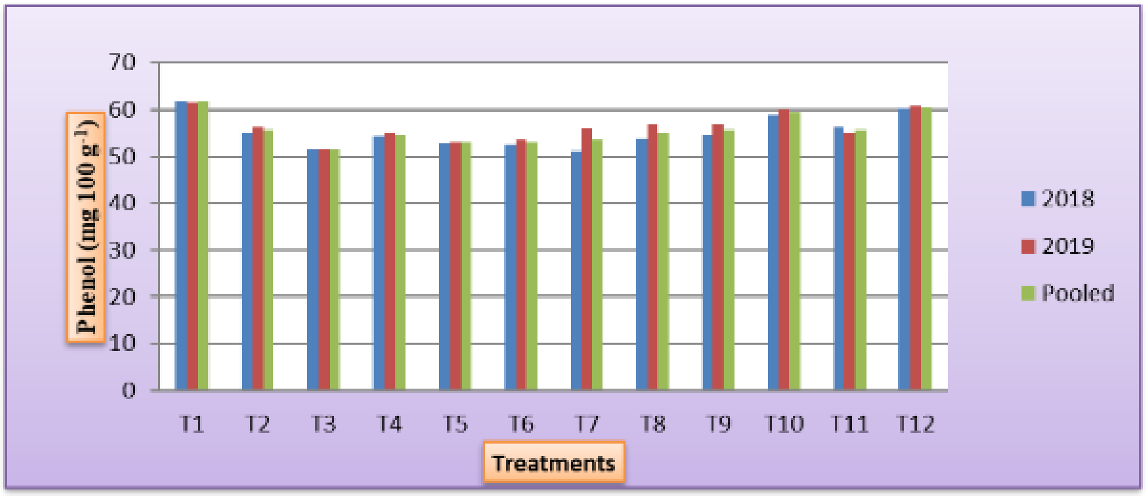

Fig 1: Effect of different treatments on phenol content (mg 100 g^{-1}) in onion

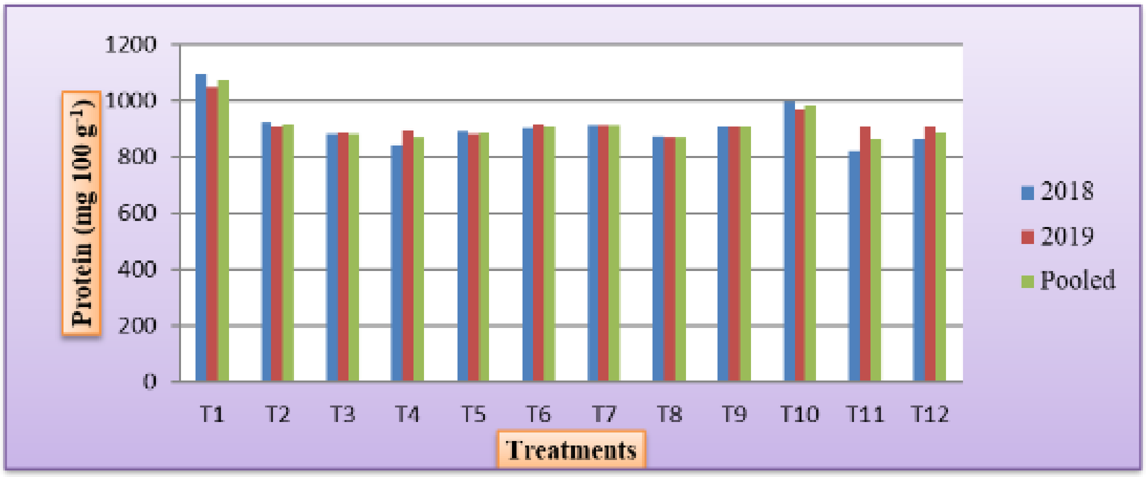

Fig 2: Effect of different treatments on protein content (mg 100 g^{-1}) in onion

Table 1: Effect of different treatments on chlorophyll content of leaves (mg 100g^{-1}) of onion

Treatments	Chlorophyll content of leaves (mg 100 g^{-1})								
	45 DATP			60 DATP			90 DATP		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T_1: GA_3 25 mg l^{-1}	1.08	1.04	1.06	2.55	2.73	2.64	2.22	2.41	2.32
T_2: GA_3 50 mg l^{-1}	0.92	0.91	0.92	2.15	2.24	2.20	1.84	2.03	1.93
T_3: GA_3 75 mg l^{-1}	0.85	0.86	0.86	2.21	2.45	2.33	1.99	2.15	2.07
T_4: NAA 25 mg l^{-1}	0.85	0.85	0.85	1.56	1.57	1.57	1.31	1.43	1.37
T_5: NAA 50 mg l^{-1}	0.89	0.94	0.92	2.00	2.30	2.15	1.71	1.73	1.72
T_6: NAA 75 mg l^{-1}	0.87	0.89	0.88	2.22	2.40	2.31	1.91	2.12	2.02
T_7: GA_3 25 mg l^{-1} + NAA 25 mg l^{-1}	0.91	0.86	0.89	2.28	2.23	2.25	1.95	2.16	2.06
T_8: GA_3 25 mg l^{-1} + NAA 50 mg l^{-1}	0.94	0.95	0.94	2.19	2.32	2.25	1.90	2.18	2.04
T_9: GA_3 25 mg l^{-1} + NAA 75 mg l^{-1}	0.90	0.92	0.91	2.09	2.17	2.13	1.73	1.86	1.80
T_{10}: GA_3 50 mg l^{-1} + NAA 50 mg l^{-1}	0.93	0.96	0.95	2.29	2.37	2.33	1.88	2.04	1.96
T_{11}: GA_3 75 mg l^{-1} + NAA 75 mg l^{-1}	0.86	0.82	0.84	1.73	1.87	1.80	1.43	1.49	1.46
T_{12}: Control	0.84	0.80	0.82	1.59	1.76	1.68	1.35	1.46	1.41
Year Mean	0.90	0.90	0.90	2.07	2.20	2.14	1.77	1.92	1.85
S. Em. ±	0.02	0.03	0.01	0.05	0.06	0.04	0.05	0.05	0.03
C.D. at 5%	0.06	0.08	0.05	0.16	0.18	0.12	0.13	0.14	0.10
C.V.%	3.88	4.94	4.44	4.49	4.86	4.69	4.46	4.32	4.39
YT: S. Em. ±			0.02			0.06			0.05
YT: C. D. at 5%			NS			NS			NS

Table 2: Effect of different treatments on reducing sugar, total sugar and non-reducing sugar of onion

Treatments	Reducing sugar (%)			Total sugar (%)			Non-reducing sugar (%)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T_1: GA_3 25 mg l^{-1}	4.67	4.62	4.65	5.69	5.73	5.71	1.02	1.11	1.07
T_2: GA_3 50 mg l^{-1}	4.26	4.63	4.44	5.60	5.95	5.78	1.34	1.32	1.33
T_3: GA_3 75 mg l^{-1}	4.84	6.62	5.73	5.65	7.35	6.50	0.81	0.73	0.77
T_4: NAA 25 mg l^{-1}	5.21	4.15	4.68	5.80	7.02	6.41	0.59	3.00	1.80
T_5: NAA 50 mg l^{-1}	4.98	5.24	5.11	6.26	7.55	6.90	1.28	2.31	1.80
T_6: NAA 75 mg l^{-1}	4.85	3.89	4.37	5.55	8.65	7.10	0.70	4.76	2.73
T_7: GA_3 25 mg l^{-1} + NAA 25 mg l^{-1}	4.03	5.15	4.59	5.15	6.52	5.84	1.12	1.37	1.25
T_8: GA_3 25 mg l^{-1} + NAA 50 mg l^{-1}	4.09	5.09	4.59	6.60	6.93	6.77	2.51	1.84	2.18
T_9: GA_3 25 mg l^{-1} + NAA 75 mg l^{-1}	4.87	4.05	4.46	5.94	8.46	7.20	1.07	4.41	2.74
T_{10}: GA_3 50 mg l^{-1} + NAA 50 mg l^{-1}	4.11	5.33	4.72	6.94	6.97	6.95	2.82	1.67	2.25
T_{11}: GA_3 75 mg l^{-1} + NAA 75 mg l^{-1}	4.08	4.59	4.34	5.72	5.91	5.82	1.64	1.35	1.49
T_{12}: Control	3.67	4.88	4.28	5.06	7.07	6.07	1.39	2.20	1.79
Year Mean	4.47	4.85	4.66	5.83	7.01	6.42	1.36	2.17	1.76
S. Em. ±	0.13	0.13	0.47	0.14	0.20	0.51	0.03	0.06	0.81
C.D. at 5%	0.37	0.39	NS	0.40	0.59	NS	0.09	0.17	NS
C.V.%	4.86	4.70	4.78	4.06	4.96	0.17	3.90	4.72	4.62
YT: S. Em. ±			0.13			0.49			0.05
YT: C. D. at 5%			0.37			4.63			0.14

Table 3: Effect of different treatments on TSS (%) and moisture content (%) of onion

Treatments	TSS (%)			Moisture content (%)		
	2018	2019	Pooled	2018	2019	Pooled
T_1: GA_3 25 mg l^{-1}	15.20	16.17	15.68	82.10	81.09	81.60
T_2: GA_3 50 mg l^{-1}	14.17	12.67	13.42	82.73	79.15	80.94
T_3: GA_3 75 mg l^{-1}	13.43	14.00	13.72	83.49	79.50	81.50
T_4: NAA 25 mg l^{-1}	14.70	15.00	14.85	79.26	78.90	79.08
T_5: NAA 50 mg l^{-1}	14.37	15.00	14.68	84.36	82.62	83.49
T_6: NAA 75 mg l^{-1}	14.40	15.58	14.99	84.89	83.07	83.98
T_7: GA_3 25 mg l^{-1} + NAA 25 mg l^{-1}	14.87	15.33	15.10	78.81	81.03	79.92
T_8: GA_3 25 mg l^{-1} + NAA 50 mg l^{-1}	13.87	15.75	14.81	82.68	82.71	82.69
T_9: GA_3 25 mg l^{-1} + NAA 75 mg l^{-1}	15.03	15.33	15.18	80.86	80.56	80.71
T_{10}: GA_3 50 mg l^{-1} + NAA 50 mg l^{-1}	13.87	15.30	14.58	82.03	81.14	81.59
T_{11}: GA_3 75 mg l^{-1} + NAA 75 mg l^{-1}	14.73	14.83	14.78	81.77	82.97	82.37
T_{12}: Control	13.73	15.00	14.37	79.16	78.47	78.81
Year Mean	14.36	15.00	14.68	81.85	80.93	81.39
S. Em. ±	0.31	0.38	0.43	1.33	1.09	0.86
C.D. at 5%	0.92	1.12	NS	3.89	3.18	2.44
C.V.%	3.80	4.42	4.14	2.81	2.32	2.58
YT: S. Em. ±			0.35			1.21
YT: C. D. at 5%			1.00			NS

Table 4: Effect of different treatments on ascorbic acid (mg $100g^{-1}$) and bulb pH of onion

Treatments	Ascorbic acid (mg 100 g^{-1})			Bulb pH		
	2018	2019	Pooled	2018	2019	Pooled
T_1: GA_3 25 mg l^{-1}	10.41	10.50	10.45	4.48	4.61	4.55
T_2: GA_3 50 mg l^{-1}	8.40	8.41	8.40	4.63	4.60	4.62
T_3: GA_3 75 mg l^{-1}	8.47	8.52	8.49	4.77	4.72	4.75
T_4: NAA 25 mg l^{-1}	8.67	8.89	8.78	4.60	4.59	4.59
T_5: NAA 50 mg l^{-1}	9.24	9.27	9.25	4.67	4.74	4.71
T_6: NAA 75 mg l^{-1}	8.79	8.52	8.66	4.74	4.77	4.76
T_7: GA_3 25 mg l^{-1} + NAA 25 mg l^{-1}	8.28	9.61	8.95	4.65	4.65	4.65
T_8: GA_3 25 mg l^{-1} + NAA 50 mg l^{-1}	9.43	9.45	9.44	4.67	4.52	4.59
T_9: GA_3 25 mg l^{-1} + NAA 75 mg l^{-1}	8.74	8.63	8.68	4.68	4.59	4.64
T_{10}: GA_3 50 mg l^{-1} + NAA 50 mg l^{-1}	9.81	9.38	9.60	4.62	4.67	4.65
T_{11}: GA_3 75 mg l^{-1} + NAA 75 mg l^{-1}	8.46	8.40	8.43	4.78	4.70	4.74
T_{12}: Control	8.10	8.22	8.16	4.76	4.38	4.57
Year Mean	8.90	8.98	8.94	4.67	4.63	4.65
S. Em. ±	0.21	0.26	0.18	0.06	0.07	0.07
C.D. at 5%	0.62	0.75	0.50	0.17	0.20	NS
C.V.%	4.10	4.93	4.54	2.12	2.58	2.36
YT: S. Em. ±			0.23			0.06
YT: C. D. at 5%			NS			0.18

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