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Growth, quality, nutrient content and uptake and soil fertility status of wheat (*Triticum aestivum* L.) as influenced by thiourea and thioglycollic acid

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Abstract
A field experiment was carried out on medium black calcareous clayey soil of Instructional Farm, Department of Agronomy, Junagadh during *rabi* season of 2017-18 to investigate the role of foliar spray of bio-regulators (thiourea and thioglycollic acid) on wheat. The experiment was comprised of four level of thiourea (water spray, 250, 500 and 1000ppm) and three level of thioglycollic acid (water spray, 100 and 200ppm) sprayed twice at tillering and flowering stages. The experiment was laid out in randomized block design having factorial concept and replicated thrice. Experimental results indicated that with increasing concentration of thiourea up to 500ppm recorded significantly higher plant height, dry matter accumulation at harvest, number of tillers per plant, protein content, chlorophyll content (SPAD value), nitrogen and phosphorus content and uptake in grain and straw over water spray and 250ppm thiourea but remained at par with 1000ppm thiourea. Similarly foliar application of thioglycollic acid @100ppm, being at par with 200ppm significantly increased all growth parameters, protein content, chlorophyll content (SPAD value), N and P content and uptake in grain and straw over water sprayed control. Foliar application of thiourea and thioglycollic acid did not significantly influenced available nitrogen, phosphorus and potassium content in soil after harvest of wheat crop.

Keywords: Wheat, thiourea, thioglycollic acid, bio-regulators

Introduction
Wheat occupies the prime position among the 'staff of life' cereals. Wheat represents the most important source of complex carbohydrates in human diet and one of the most abundant sources of energy and proteins for the world population. Wheat is the staple food mainly used for making bread, biscuits, cookies, cakes, noodles etc. It contains 71.20% carbohydrates, 11.80% proteins, 1.50% fats, 1.50% mineral matter, 0.05% calcium and 0.32% phosphorus (Swaminathan *et al.,* 1981) [24]. It is grown all over the world for its wider adaptability and high nutritive value. The major wheat producing states in India are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, Gujarat and Maharashtra. It is grown in India under sub-tropical environment during *rabi* season and occupies an area of 39.72 million hectares with the production of 98.61 million tonnes and productivity of 3310kg/hectare (Anonymous, 2018) [2]. In Gujarat, wheat occupies an area of 1.06 million hectares with a production of 3.052 million tonnes and productivity of 2890kg/ha (Anonymous, 2018) [2].

There are several reasons of low productivity and one of them is improper sink-source relationship and internal hormonal imbalance which are of primary importance. Application of SH-compounds has potential for improving phloem translocation of photosynthates, quality and uptake of nutrients. Thus, they act as bio-regulator and play an important role in improving water use efficiency through enhanced phloem translocation and yield formation. In recent years, use of bio-regulators has offered new avenues for enhancing productivity of several crops. Plant bio-regulators are biochemical compounds which stimulates plant growth and productivity when applied, even in small quantities at appropriate plant growth stages. These are being extensively used in agriculture to enhance the productivity in field crops. Their central role in plant growth and development is through nutrient allocation and source-sink transitions.

Application of thiourea and thioglycollic acid has been reported to induce higher physiological efficiencies of plants which resulted in better growth. The favourable effect on growth of plants may also be due to on account of improved photosynthetic efficiency, as thiourea has been reported to stimulate dark fixation of CO_2 in embryonic axes (Hernadez- Nistal *et al*., 1983) [8]. Thiourea and SH containing thiols have been reported to increase the chlorophyll content (Seth *et al.,* 2004) [18] and decrease a stress-induced drop in PS-I and PS-II activities in wheat under water stress (Nathawat *et al.,* 2007) [11] and (Burman, 2007).

The positive effect of bio-regulators on N, P concentration and uptake of nitrogen, phosphorus and potassium can be attributed to the fact that foliar application of bio-regulators helps in better root growth, which might have helped in their deep penetration to soil to extract more nutrients (Swaminathan,1980) [23].

Materials and Methods

The investigation was conducted at Instructional Farm, Department of Agronomy, JAU, Junagadh, and Gujarat during *rabi* season of year 2017-18. The soil of experimental site was clayey in texture with pH 7.67 and EC 0.52dS/m. The soil was low in available nitrogen (245.20kg/ha), medium in available phosphorus (35.10kg/ha) and potassium (270.70kg/ha). The treatment was laid out in Factorial Randomized Block Design with three replications. The treatments consisted of foliar spray of thiourea (water spray, 250, 500 and 1000ppm) and thioglycollic acid (water spray, 100 and 200ppm). Foliar spray was done at tillering (35 DAS) and flowering (65 DAS) stages using spray volume of 600 litre/ha. Wheat (GW 366) was sown in field plots on November 17th, 2017 at a depth of 4-5cm keeping inter row spacing of 22.5cm using recommended seed rate 120kg/ha. Recommended dose of nitrogen, phosphorus and potassium (120-60-60 N, P_2O_5, K_2O kg/ha) in the form of urea, DAP (Di-ammonium phosphate) and MOP (Muriate of potash) was applied in each plot. The first irrigation was given immediately after sowing. The subsequent irrigations were applied at critical stages and as per need for successful wheat production. Other agronomic practices and disease pest management were followed as per the recommendations. Observations were recorded on growth parameters, protein content and chlorophyll content (SPAD value), NPK content and uptake and soil fertility status after harvest of wheat crop. Statistical analysis of data was carried out for each character as described by Panse and Sukhatme (1985) [13]. Critical difference (CD) values at P=0.05 were used for determine the significance of differences between mean values of treatments.

Results and Discussion

Growth parameters

Plant height

A critical examination of data Table 1 indicated that foliar spray of thiourea and thioglycollic acid significantly improved plant height at 60, 90 DAS and at harvest. Maximum plant height at 60 DAS (64.94cm) was recorded with the foliar application of thiourea @1000ppm but remained at par with thiourea @250 and 500ppm. Significantly higher plant height at 90 DAS (94.19cm) and harvest (98.21cm) was obtained with 1000ppm thiourea and remained at par with 500ppm thiourea spray. The foliar application of 200ppm thioglycollic acid significantly recorded highest plant height at 60 DAS (63.69cm), 90 DAS (92.28cm) and at harvest (95.56cm) over water spray but remained at par with 100ppm thioglycollic acid. This might be due to that the foliar application thiourea increases the plant photosynthetic efficiency and canopy photosynthesis due to presence of-SH group as an integral constituent of these thiols. Significant increase in LAI, LAD and dry matter accumulation as a result of thiourea application provided ample support to such effects (Sahu, 1993) [17]. The increase in dry matter accumulation with the foliar spray of bio-regulators could be attributed to an increase in the plant height as a result of cell elongation and cell enlargement, consequently plant might produced longer and thicker stems and hence, the dry matter accumulation might have increased. Similar results were also reported by Singh (2010) [22], Dhikwal *et al*. (2012) [6], Sharma (2016) [20] and Yadav *et al.* (2018) [26].

Dry matter accumulation

Data presented in Table 1 revealed that the foliar application of thiourea @1000ppm at tillering and flowering stages recorded significantly higher dry matter accumulation at 60 DAS (10.64g/plant) over water spray and remained at par with foliar spray of 250 and 500ppm thiourea. Further significantly higher dry matter accumulation at 90 DAS (20.04g/plant) and harvest (22.23g/plant) recorded with 1000ppm thiourea over water spray control and 250ppm thiourea but remained at par with 500ppm thiourea. The foliar application of 200ppm thioglycollic acid significantly increased the dry matter accumulation as compared to water sprayed control but remained at par with thioglycollic acid @100ppm at 60 DAS (10.48g/pant), 90 DAS (19.63g/plant) and at harvest (21.76 g/plant), respectively. This might be due to that the-SH group stimulated the photosynthetic carbon fixation mechanism and hence, foliar spray of bio-regulators might have increased the LAI and canopy photosynthesis, which ultimately resulted in higher growth of wheat. These results are in agreement with the finding of Dhikwal *et al*. (2012) [6], Dadhich *et al.* (2015) [5], Rana (2015) [15] and Yadav *et al.* (2018) [26].

Number of tillers per plant at harvest

Scrutiny examination of data presented in Table 1 revealed that significantly the highest tillers per plant at harvest (5.55) was recorded under the foliar spray of thiourea @1000ppm, which was found statistically at par with the foliar application of thiourea @500ppm. The increase in tillers per plant with application of thiourea @500 and 1000ppm was 9.54 and 10.34 per cent respectively, over water spray. Significantly the highest number of tillers per plant (5.45) was recorded under the foliar spray of thioglycollic acid @200ppm over control but remained at par with thioglycollic acid (TGA) spray @100ppm. Results of Dhikwal *et al.* (2012) [6], Rana (2015) [15], Amin *et al.* (2016) [1] and Yadav *et al.* (2018) [26] also confirms the same.

Quality parameters

Protein content (%)

An assessment of data (Table 2) revealed that protein content in wheat grain varied significantly due to foliar application of various concentrations of TU. Maximum protein content (12.37%) in wheat grain recorded with 1000ppm thiourea and remained at par with 500ppm thiourea spray. Foliar spray of 200ppm thioglycollic acid (TGA) recorded significantly higher protein content in wheat grain (12.09%) over control and it remained at par with 100ppm thioglycollic acid. The more protein content in seed might be due to increased concentration of nitrogen in seeds of wheat by foliar spray of thiourea. The present finding is within close vicinity of those reported by Sachan (1991) [16], Dhikwal *et al.* (2012) [6] and Gupta (2015) [7].

Chlorophyll content

An evident of data presented in Table 2 revealed that the foliar application of thiourea @1000ppm, being at par with 250 and 500ppm thiourea (TU) recorded significantly higher chlorophyll content (SPAD value) over control at 42 DAS.

Further perusal of data indicated that the highest chlorophyll content (SPAD value) was recorded with the foliar application of 1000ppm thiourea which was significantly higher over control and 250ppm thiourea but remained at par with 500ppm thiourea at 72 DAS. Leaf chlorophyll content (SPAD value) significantly increased with thioglycollic acid @100ppm over control but found at par with 200ppm thioglycollic acid at 42 and 72 DAS, respectively. Similar results were also reported by Sekhawat (1998) [21], Rana (2015) [15], Nathawat *et al.* (2016) [12] and Sharma (2016) [20].

Nutrient Content and Uptake of NPK

Nutrient content in grain and straw

A close look of data (Table 3) revealed that foliar application of thiourea @1000ppm significantly increased nitrogen and phosphorus content in grain and straw over water spray and 250ppm thiourea but remained at par with 500ppm thiourea. Significant increase in nitrogen and phosphorus content in grain and straw was observed with the foliar application of thioglycollic acid @100ppm over control but at par with 200ppm thioglycollic acid. However, the foliar application of thiourea and thioglycollic acid did not significantly influenced the potassium content in grain and straw.

Nutrient uptake by grain and straw

It is explicit from data presented in Table 3 that nitrogen, phosphorus and potassium uptake by grain and straw in wheat were significantly higher with the foliar application of 500ppm thiourea, which remained statistically at par with thiourea @1000ppm. Crop under foliar application of TGA (200ppm) recorded significantly the higher nitrogen, phosphorus and potassium uptake by grain and straw than control in wheat, which remained statistically at par with 100ppm thioglycollic acid. The results are in conformity with those reported by Yadav (2005) [25], Sharma *et al.* (2012) [19], Gupta (2015) [7] and Rana (2015) [15] Kumawat *et al.* (2013) and Sharma (2016) [20].

Poat-Harvest Nutrient Status of Soil

It is obvious from the data in Table 4 that different levels of foliar spray of thiourea and thioglycollic acid did not influenced available nitrogen, phosphorus and potassium of soil after harvest of wheat. Similar result was also recorded by Bochalia (2008) [3], Ram *et al.* (2009) [14] and Jeengar (2012) [9].

Conclusion

Based on the one year experimental results, it seems quite logical to concluded that foliar application of 500ppm thiourea or 100ppm thioglycollic acid at tillering and flowering stages, being at par with 1000ppm thiourea or 200ppm thioglycollic acid significantly increased plant height, dry matter accumulation, number of tillers per plant, protein content, chlorophyll content, nitrogen and phosphorus content in grain and straw and NPK uptake by grains and straw of wheat.

Table 1: Effect of bio-regulators on plant height, dry matter accumulation and number of tillers of wheat

Treatments	Plant height (cm)			Dry matter accumulation (g/plant)			Number of tillers (per plant) At harvest
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	
Thiourea (ppm)							
S_0 : 0 (Water spray)	56.31	83.81	84.88	9.16	17.57	19.58	5.03
S_1 : 250	59.57	85.02	88.10	9.76	18.24	20.20	5.12
S_2 : 500	61.28	91.34	97.38	10.52	19.81	21.94	5.51
S_3 : 1000	64.94	94.19	98.21	10.64	20.04	22.23	5.55
SEm±	1.56	2.54	2.59	0.34	0.53	0.58	0.13
CD (P = 0.05)	4.57	7.45	7.58	1.00	1.55	1.70	0.38
Thioglycollic acid (ppm)							
T_0 : 0 (Water spray)	57.74	83.39	87.11	9.18	17.60	19.61	5.05
T_1 : 100	60.14	90.09	93.75	10.40	19.52	21.60	5.42
T_2 : 200	63.69	92.28	95.56	10.48	19.63	21.76	5.45
SEm±	1.35	2.20	2.24	0.30	0.46	0.50	0.11
CD (P = 0.05)	3.96	6.45	6.57	0.87	1.34	1.47	0.33

Table 2: Effect of bio-regulators on protein and chlorophyll content (SPAD value) of wheat

Treatments	Protein content (%)	Chlorophyll content at 42 DAS	Chlorophyll content at 72 DAS
Thiourea (ppm)			
S_0 : 0 (Water spray)	10.65	47.22	42.24
S_1 : 250	11.05	50.37	45.13
S_2 : 500	12.17	54.16	48.92
S_3 : 1000	12.37	55.30	50.03
SEm±	0.17	1.68	1.28
CD (P = 0.05)	0.49	4.94	3.76
Thioglycollic acid (ppm)			
T_0 : 0 (Water spray)	10.66	47.37	42.38
T_1 : 100	11.94	53.88	48.62
T_2 : 200	12.09	54.04	48.75
SEm±	0.15	1.46	1.11
CD (P = 0.05)	0.43	4.28	3.26

Table 3: Effect of bio-regulators on content and uptake of NPK by wheat

Treatments	Nitrogen content (%)		Nitrogen uptake (kg/ha)		Phosphorus content (%)		Phosphorus uptake (kg/ha)		Potassium content (%)		Potassium uptake (kg/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Thiourea (ppm)												
S_0 : 0 (Water spray)	1.704	0.300	69.66	16.91	0.400	0.128	16.37	7.20	0.509	1.138	20.85	64.09
S_1 : 250	1.768	0.313	75.39	18.21	0.419	0.134	17.88	7.84	0.522	1.148	22.29	66.84
S_2 : 500	1.948	0.325	92.50	21.36	0.448	0.144	21.13	9.50	0.528	1.180	24.90	77.45
S_3 : 1000	1.980	0.328	94.95	21.70	0.457	0.147	21.83	9.69	0.533	1.185	25.33	77.94
SEm±	0.027	0.005	2.83	0.95	0.006	0.002	0.60	0.40	0.008	0.018	0.76	2.93
CD (P = 0.05)	0.079	0.014	8.29	2.78	0.019	0.006	1.77	1.18	NS	NS	2.23	8.60
Thioglycollic acid (ppm)												
T_0 : 0 (Water spray)	1.705	0.306	70.08	17.32	0.409	0.131	16.85	7.45	0.513	1.136	21.14	64.29
T_1 : 100	1.910	0.320	88.69	20.51	0.438	0.140	20.27	8.99	0.527	1.173	24.30	74.65
T_2 : 200	1.934	0.323	90.61	20.81	0.446	0.143	20.79	9.23	0.529	1.179	24.60	75.81
SEm±	0.023	0.004	2.45	0.82	0.006	0.002	0.52	0.35	0.007	0.015	0.66	2.54
CD (P = 0.05)	0.068	0.012	7.18	2.41	0.016	0.005	1.53	1.02	NS	NS	1.93	7.45

Table 4: Effect of bio-regulators on nutrient status of soil after harvest of wheat crop

Treatments	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
Thiourea (ppm)			
S_0 : 0 (Water spray)	218	23.1	222
S_1 : 250	220	23.2	224
S_2 : 500	225	24.2	230
S_3 : 1000	226	24.3	232
SEm±	3.69	0.38	3.56
CD (P = 0.05)	NS	NS	NS
Thioglycollic acid (ppm)			
T_0 : 0 (Water spray)	218	23.0	222
T_1 : 100	224	24.0	229
T_2 : 200	225	24.1	230
SEm±	3.19	0.33	3.08
CD (P = 0.05)	NS	NS	NS

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