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Growth and growth indices of durum wheat as influenced by seed soaking and foliar spray of stress mitigating bio-regulators under conserved soil moisture condition

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Abstract

In order to investigate the effect of seed soaking and foliar spray of stress- mitigation bio-regulators on growth and growth indices of durum wheat under conserved moisture condition of *Bhal* tract of Gujarat in rabi season cultivation 2017-18 & 2108-19. The experiment was done in randomized block design (factorial) with four replications, two factors & four levels, (A) Seed soaking (S₀: No seed soaking, S₁: Seed soaking with water, S₂: Seed soaking with salicylic acid (100 ppm) & S₃: Seed soaking with thiourea (500 ppm)), (B) Foliar spray (C₀: No spray, C₁: Water spray, C₂: Salicylic acid spray (100 ppm) & C₃: Thiourea spray (1000 ppm)). The foliar spray of stress- mitigation bio-regulators was done on tillering and ear emergence stages of crop. The impact of seed soaking & foliar spray with salicylic acid (100 ppm) was found significant over control in respect to plant height at 60 and 90 DAS and at harvest, dry matter accumulation at 60 and 90 DAS and at harvest, Crop growth rate (CGR) at 30-60 DAS, 60-90 DAS and 90 DAS to harvest, Relative growth rate (RGR) at 30-60 DAS, 60-90 DAS and 90 DAS to harvest, Leaf area index (LAI) at 90 DAS, Leaf area ratio (LAR) at 30-60 DAS and 60-90 DAS and in case of net assimilation rate (NAR) the significant data was found seed soaking with salicylic acid (100 ppm) at 30-60 DAS and 60-90 DAS. The study clearly indicated that seed soaking & foliar spray with salicylic acid (100 ppm) was performed better than over control.

Keywords: Seed soaking, foliar spray, salicylic acid, RGR, CGR, LAI and ANR

Introduction

There are four species viz; *Triticum aestivum*, *Triticum durum*, *Triticum monoccum* and *Triticum dicoccum* which cultivated in India. Durum wheat (*Triticum durum* L.), define as a separate commodity, has yet to find its rightful place in India. Its production in the country varies between 2-5% of total wheat production. It is worth mentioning that durum wheat sells at a premium to other varieties and accounts for roughly 5% of global wheat production. Its high protein content (12 to 14%), β Carotene (2.11 ppm) and gluten strength make durum good for pasta and bread. Semolina made from durum is used for premium pastas and breads. There is also a red durum, used mostly for livestock feed. Most durum wheat is grown in Mediterranean countries, the former Soviet Union, North America, and Argentina. Durum wheat comprises a small portion of the total wheat grown in India. It is grown mainly in the central zone which includes the states of Madhya Pradesh, Gujarat, parts of Punjab, south Rajasthan, and Maharashtra. (Ann. 2005) ^[1]. Besides moisture stress, heat stress is also a very important factor that affects the agricultural production worldwide due to climate change (Hall, 2011) ^[5]. Salicylic acid is a lipophilic monohydroxybenzoic acid, a type of phenolic acid, and a beta hydroxy acid (BHA). Phenolics are aromatic benzene ring compounds with one or more hydroxyl groups produced by plants mainly for protection against stress. The functions of phenolic compounds in plant physiology and interactions with biotic and abiotic environments are difficult to overestimate. Bio-regulators are the group of chemicals which regulated the efficiency of plant i e, physiological & bio- chemical activity. Bio-regulators have a lot of group of chemicals such as thiourea, Salicylic acid and Thio- Salicylic acid etc. According to Shrama *et al.* (2008) ^[14] response of wheat to foliar application of bio-regulators, significantly improve growth parameters of crop. Singh *et al.*, (2013) ^[15] reported that spray of kinetin, thiourea and TGA being at par significantly increased grain yield, straw yield and harvest index as compared to water spray. Hayat *et al.*, (2003) ^[8] reported that salicylic acid sprayed on mustard (*Brassica juncea* L.) recorded higher net photosynthetic rate, number of

silique and seed yield over control. Hayata *et al.*, (2010) [7] found that exogenous application of the lower concentration of salicylic acid proved to be beneficial in enhancing the photosynthesis, growth and various other physiological and biochemical characteristics of plants. Lin Lingna *et al.*, (2011) [11] observed that salicylic acid pretreatments with satisfactory concentrations between 25 to 400 μM proved to enhance heat tolerance in the wax begonia.

Materials and Method

A field experiment was conducted at Agricultural Research Station, Anand Agricultural University, Dhandhuka, Bhal and Coastal Zone of Gujarat in Ahmedabad district at 22° 22' North Latitude and 71° 59' East Longitude during *rabi* season 2017-18 & 2018-19. The climate of this region is semi-arid and sub-tropical. Monsoon commences by the second week of June and retreats by middle of September with an average rainfall of 625.5 mm received entirely from the south-west monsoon currents. During both the years of experimentations, there was no rainfall recorded. Crop was sown under conserved soil moisture condition which is received during rainy season. Experiment was laid out in Randomized Block Design (Factorial) with four replications. A total of sixteen treatments comprised of different seed soaking and foliar spray of treatments. The line-to-line distance was kept as 30 cm with plant to plant distance of 10 cm with a seed rate of 60 kg ha⁻¹ and seed soaking for one hour and foliar spray were applied at two stages of crop *viz*: tillering and ear emergence.

Methodology followed for recording observations on growth and growth indices

Plant height (cm): The height of previously selected and tagged five plants was recorded from ground level to the top of the last fully opened leaf at 30 DAS, while the height was measured from ground level to base of spike at 60, 90 DAS and at harvest.

Dry matter accumulation (g): The periodical change in dry matter accumulation at successive growth stages *i.e.*, 30, 60, 90 DAS and at harvest was recorded by collecting whole plant samples from the randomly selected area in each plot.

Crop growth rate (CGR): The CGR of a plant for a time 't' is defined as the increase in dry weight of plant material from a unit area per unit of time. It was calculated by following formula (Radford, 1967) [12] from periodic dry matter record at different stages between 30-60, 60-90 DAS and 90 to at harvest.

$$\text{CGR (g/m}^2\text{/day)} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_1 = Dry matter of crop at time t_1 , W_2 = Dry matter of crop at time t_2

t_1 = Time of first observation, t_2 = Time of last observation.

Relative growth rate (RGR): RGR of a plant at an instant in time (t) is defined as the increase in dry weight of plant material per unit of material already present per unit of time. The RGR of the crop was calculated by the following formula (Radford, 1967) [12] at 30-60, 60-90 DAS and 90 to at harvest.

$$\text{RGR (mg/g/day)} = \frac{(\text{Log}_e W_2 - \text{Log}_e W_1)}{t_2 - t_1}$$

Where

W_1 = Total dry matter of crop at time t_1 , W_2 = Total dry matter of crop at time t_2

t_1 = Time at first observation, t_2 = Time at second observation

Leaf area ratio (LAR): LAR of a plant at an instant in time 't' is defined as the ratio of the assimilatory material per unit of plant material present. It was calculated according to following formula (Radford, 1967) [12] at 30-60, 60-90 DAS and 90 to at harvest.

$$\text{LAR (cm}^2\text{/g)} = \frac{A_2 - A_1}{(W_2 - W_1)} \times \frac{(\text{Log}_e W_2 - \text{Log}_e W_1)}{(\text{Log}_e A_2 - \text{Log}_e A_1)}$$

Where

W_1 = Total dry matter of plant at time t_1 ,

W_2 = Total dry matter of plant at time t_2 ,

A_1 = Total leaf area (m^2) at time t_1 ,

A_2 = Total leaf area (m^2) at time t_2

t_1 = Time of first observation,

t_2 = Time of second observation

Leaf area index (LAI): Leaf area index was calculated at 90 DAS as per the procedure given by Sestak *et al.*, (1971).

$$\text{LAI} = \frac{\text{Leaf area of one tiller (cm}^2\text{) x no of tillers in one m}^2}{10,000}$$

Net assimilation rate (NAR): Is an increase in plant material per unit leaf area per unit time. The NAR is calculated by the following formula (Radford, 1967) [12] at 30-60, 60-90 DAS and 90 to at harvest.

$$\text{NAR (g/m}^2\text{ leaf area/day)} = \frac{(W_2 - W_1) (\text{Log}_e L_2 - \text{Log}_e L_1)}{(t_2 - t_1) (L_2 - L_1)}$$

Where

L_1 and L_2 are total leaf area at time t_1 and t_2 , respectively. W_1 and W_2 are total dry weight at time t_1 and t_2 , respectively.

Results and Discussion

Growth parameters and growth indices of durum wheat differed significantly with seed soaking and foliar spray of stress mitigating bio-regulators. The character such as plant height, dry matter accumulation, crop growth rate, relative growth rate, relative growth rate, leaf area ratio, leaf area index and net assimilation rate differ due to seed soaking and foliar spray bio-regulators.

Plant height (cm)

Seed soaking: Application of seed soaking (Table 1.0) with salicylic acid (100 ppm) represented an increase to the tune of 14.15 and 12.39 percent at 60 DAS, 10.40 and 8.89 percent at 90 DAS and 11.62 and 8.89 percent at harvest over no soaking (S_0) and water soaking (S_1), respectively on pooled basis. The treatment of seed soaking with thiourea (500 ppm) (S_3) being at par during both the years as well as in pooled analysis at 60 and 90 DAS and at harvest proved significantly

superior over control. The favorable effect of salicylic acid on growth of plants might be due to it involves in nutrient uptake and translocation, water and stomatal regulations and antioxidant defense (Arfan *et al.*, 2007) [2].

Foliar spray: Foliar spray with 100 ppm salicylic acid spray (C₂) enhanced the plant height up to 12.82 and 10.74 per cent at 60 DAS, 10.03 and 8.61 per cent at 90 DAS and 10.57 and 7.60 per cent at harvest over no spray (C₀) and water spray (C₁) on pooled basis, respectively. A beneficial effect of foliar spray with salicylic acid @ 100 ppm found to generate a wide range of metabolic and physiological responses in plants (Hayat *et al.* 2010) [16].

Dry matter accumulation (g)

Seed soaking: A perusal of data indicated (Table 2.0) that

seed soaking with salicylic acid (100 ppm) recorded a significant increase of 20.18 and 17.60 per cent at 60 DAS, 28.69 and 23.03 per cent at 90 DAS and 30.71 and 24.46 per cent at harvest for dry matter accumulation over no seed soaking (S₀) and seed soaking with water (S₁) on pooled basis, respectively. Seed soaking with salicylic acid increased tiller density, dry matter accumulation, leaf area index (Jatana *et al.*, 2020) [10].

Foliar spray: Due to foliar spray with 100 ppm salicylic acid (C₂) the magnitude of increase was 19.72 and 17.36 per cent at 60 DAS, 21.51 and 18.78 per cent at 90 DAS, 24.82 and 20.26 per cent at harvest over no foliar spray (C₀) and foliar spray with water (C₁), respectively, on pooled mean basis. But foliar application of any of the bio-regulators could not influenced dry matter accumulation at 30 DAS.

Table 1: Effect of seed soaking and foliar spray of stress mitigating bio-regulators on periodical plant height of wheat

Treatments	Plant height (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Seed soaking												
S ₀ - Control (No seed soaking)	19.81	19.91	19.86	35.31	36.50	35.91	68.32	69.53	68.93	77.19	79.27	78.23
S ₁ - Seed soaking with water	20.12	20.14	20.13	36.11	36.83	36.47	69.70	70.07	69.89	79.66	80.73	80.19
S ₂ - Seed soaking with Salicylic acid (100 ppm)	21.20	21.25	21.22	40.53	41.46	40.99	75.91	76.28	76.10	86.77	87.87	87.32
S ₃ - Seed soaking with Thiourea (500ppm)	21.12	21.16	21.14	40.05	41.27	40.66	74.14	74.34	74.24	84.96	87.05	86.01
S.Em+	0.50	0.54	0.37	0.79	0.89	0.60	1.58	1.82	1.20	2.23	1.98	1.49
CD (P = 0.05)	NS	NS	NS	2.26	2.53	1.67	4.49	5.18	3.37	6.36	5.63	4.18
Foliar spray												
C ₀ - Control (No spray)	19.85	19.92	19.89	35.68	36.67	36.18	68.51	69.68	69.10	77.84	79.65	78.75
C ₁ - Water spray	20.15	20.22	20.19	36.18	37.54	36.86	69.85	70.15	70.00	79.99	81.84	80.92
C ₂ - Salicylic acid spray (100 ppm)	21.15	21.19	21.17	40.29	41.35	40.82	75.77	76.29	76.03	86.49	87.64	87.07
C ₃ - Thiourea spray (1000 ppm)	21.10	21.13	21.12	39.85	40.49	40.17	73.95	74.10	74.03	84.26	85.78	85.02
S.Em+	0.50	0.54	0.37	0.79	0.89	0.60	1.58	1.82	1.20	2.23	1.98	1.49
CD (P = 0.05)	NS	NS	NS	2.26	2.53	1.67	4.49	5.18	3.37	6.36	5.63	4.18
S x C, Y x S, Y x C, Y x S x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	9.75	10.53	10.15	8.36	9.11	8.76	8.76	10.03	9.42	10.88	9.45	10.17

Table 2: Effect of seed soaking and foliar spray of stress mitigating bio-regulators on periodical dry matter accumulation stages of wheat

Treatments	Dry matter accumulation (g)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Seed soaking												
S ₀ - Control (No seed soaking)	17.05	17.31	17.18	91.87	93.82	92.85	152.71	151.26	151.99	207.24	203.70	205.47
S ₁ - Seed soaking with water	17.39	17.61	17.50	93.89	95.88	94.89	158.84	159.15	158.99	216.57	215.01	215.79
S ₂ - Seed soaking with Salicylic acid (100 ppm)	17.86	18.18	18.02	111.29	111.88	111.59	193.28	197.92	195.60	268.33	268.82	268.58
S ₃ - Seed soaking with Thiourea (500ppm)	17.69	17.97	17.83	109.56	110.37	109.96	187.77	194.04	190.90	259.36	262.93	261.15
S.Em+	0.37	0.39	0.27	2.53	2.66	1.83	3.88	4.33	2.91	4.66	5.36	3.55
CD (P = 0.05)	NS	NS	NS	7.20	7.58	5.14	11.06	12.33	8.15	13.28	15.27	9.95
Foliar spray												
C ₀ - Control (No spray)	17.15	17.29	17.22	92.69	93.68	93.19	155.29	159.78	157.54	208.85	213.58	211.22
C ₁ - Water spray	17.23	17.62	17.43	94.59	95.55	95.07	159.95	162.36	161.16	217.98	220.48	219.23
C ₂ - Salicylic acid spray (100 ppm)	17.85	18.16	18.01	110.65	112.49	111.57	190.44	192.39	191.42	265.49	261.78	263.64
C ₃ - Thiourea spray (1000 ppm)	17.76	17.99	17.88	108.69	110.23	109.46	186.91	187.84	187.38	259.19	254.62	256.91
S.Em+	0.37	0.39	0.27	2.53	2.66	1.83	3.88	4.33	2.91	4.66	5.36	3.55
CD (P = 0.05)	NS	NS	NS	7.20	7.58	5.14	11.06	12.33	8.15	13.28	15.27	9.95
S x C, Y x S, Y x C, Y x S x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	8.46	8.76	8.61	9.94	10.34	10.14	8.97	9.86	9.43	7.84	9.02	8.45

Crop growth rate (CGR)

Seed soaking: A perusal of data indicated (Table 3.0) that significantly higher crop growth rate was recorded with treatment S₂ (Seed soaking with Salicylic acid (100 ppm)) during 2017-18 (3.11, 2.73 and 2.50), 2018-19 (3.12, 2.87 and 2.36) and in pooled (3.12, 2.80 and 2.43) for growth phases between at 30-60 DAS, 60-90 DAS and 90 DAS to harvest,

respectively

Foliar spray: The CGR documented under salicylic acid spray (100 ppm) (C₂) was 3.09, 2.66 and 2.50 during 2017-18, 3.14, 2.66 and 2.31 during 2018-19 and 3.12, 2.66 and 2.41 on pooled basis for 30-60, 60-90 and 90-harvest periods, respectively

Relative growth rate (RGR)

Seed soaking: Seed soaking with salicylic acid (100 ppm) (S_2) showed an increase of 8.10 and 7.86, 13.88 and 8.73, and 5.21 and 3.83 percent at 30-60 DAS, 60-90 DAS and 90 DAS to harvest period, respectively over no seed soaking (S_0) and seed soaking with water (S_1) on pooled mean basis. (Table 4.0). Yadav (2005) [17] found that application of 500 ppm thiourea in wheat (seed soaking + foliar spray) significantly increased the growth parameters.

Foliar spray: The increase due to foliar spray represented by salicylic acid spray (100 ppm) treatment was to the tune of 8.03, 7.52, 2.87, 2.35, 9.11 and 4.02 per cent at 30-60, 60-90 DAS and 90 DAS-harvest over no spray and water spray treatment, respectively on pooled basis. These Findings are in close conformity with (Iqbal *et al.* 2020) [9] who reported that the salicylic acid (SA) exhibited significantly higher crop growth rate (13%), net assimilation rate (29).

Table 3: Effect of seed soaking and foliar spray of stress mitigating bio-regulators on crop growth rate (CGR) at different periodical of wheat

Treatments	Crop growth rate (g/m ² /day)								
	30-60 DAS			60-90 DAS			90 DAS-at harvest		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Seed soaking									
S_0 - Control (No seed soaking)	2.49	2.55	2.52	2.03	1.91	1.97	1.82	1.75	1.78
S_1 - Seed soaking with water	2.55	2.61	2.58	2.16	2.11	2.14	1.92	1.86	1.89
S_2 - Seed soaking with Salicylic acid (100 ppm)	3.11	3.12	3.12	2.73	2.87	2.80	2.50	2.36	2.43
S_3 - Seed soaking with Thiourea (500ppm)	3.06	3.08	3.07	2.61	2.79	2.70	2.39	2.30	2.34
S.Em+	0.07	0.07	0.05	0.06	0.07	0.05	0.06	0.06	0.04
CD (P = 0.05)	0.19	0.21	0.14	0.18	0.20	0.13	0.17	0.17	0.12
Foliar spray									
C_0 -Control (No spray)	2.52	2.55	2.53	2.09	2.20	2.15	1.79	1.79	1.79
C_1 - Water spray	2.58	2.60	2.59	2.18	2.23	2.20	1.93	1.94	1.94
C_2 - Salicylic acid spray (100 ppm)	3.09	3.14	3.12	2.66	2.66	2.66	2.50	2.31	2.41
C_3 - Thiourea spray (1000 ppm)	3.03	3.07	3.05	2.61	2.59	2.60	2.41	2.23	2.32
S.Em+	0.07	0.07	0.05	0.06	0.07	0.05	0.06	0.06	0.04
CD (P = 0.05)	0.19	0.21	0.14	0.18	0.20	0.13	0.17	0.17	0.12
S x C, Y x S, Y x C, Y x S x C	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	9.76	10.51	10.15	10.63	11.32	10.98	11.35	11.88	11.61

Table 4: Effect of seed soaking and foliar spray of stress mitigating bio-regulators on relative growth rate (RGR) at different periodical of wheat

Treatments	Relative growth rate (mg/g/day)								
	30-60 DAS			60-90 DAS			90 DAS-at harvest		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Seed soaking									
S_0 - Control (No seed soaking)	50.44	50.61	50.52	15.22	14.32	14.77	9.12	8.92	9.02
S_1 - Seed soaking with water	50.50	50.75	50.63	15.74	15.20	15.47	9.26	9.01	9.14
S_2 - Seed soaking with Salicylic acid (100 ppm)	54.80	54.42	54.61	16.53	17.11	16.82	9.80	9.17	9.49
S_3 - Seed soaking with Thiourea (500ppm)	54.61	54.36	54.49	16.13	16.92	16.53	9.65	9.10	9.38
S.Em+	0.93	1.04	0.70	0.20	0.22	0.15	0.15	0.13	0.10
CD (P = 0.05)	2.65	2.97	1.96	0.58	0.63	0.42	0.43	NS	0.28
Foliar spray									
C_0 -Control (No spray)	50.51	50.60	50.56	15.44	15.90	15.67	8.86	8.70	8.78
C_1 - Water spray	50.98	50.63	50.80	15.72	15.79	15.75	9.26	9.17	9.21
C_2 - Salicylic acid spray (100 ppm)	54.62	54.62	54.62	16.25	15.99	16.12	9.94	9.23	9.58
C_3 - Thiourea spray (1000 ppm)	54.24	54.29	54.27	16.22	15.88	16.05	9.78	9.11	9.45
S.Em+	0.93	1.04	0.70	0.20	0.22	0.15	0.15	0.13	0.10
CD (P = 0.05)	2.65	2.97	1.96	0.58	NS	0.42	0.43	0.38	0.28
S x C, Y x S, Y x C, Y x S x C	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	7.09	7.94	7.52	5.11	5.56	5.34	6.36	5.89	6.14

Leaf area ratio (LAR)

Seed soaking: Data presented in Table 5.0 the percent increase of LAR under seed soaking with salicylic acid (100 ppm) (S_2) was to the tune of 3.46 and 5.01, and 8.70 and 5.33 per cent over no seed soaking (S_0) and seed soaking with water (S_1), respectively at 30-60 DAS and 60-90 DAS period on pooled basis. LAR between 90 DAS-harvest was found non-significant during both the years and on pooled basis.

Foliar spray: A critical examination of data unveiled that foliar spray with different stress mitigating bio-regulators had different effects on LAR at different periods of wheat growth. During 30-60 DAS, foliar spray with salicylic acid (100 ppm) (C_2), being at par with C_3 (thiourea spray (1000 ppm))

significantly enhanced the LAR during both the years and pooled analysis which were 5.80 and 6.31 per cent higher over no spray (C_0) and water spray (C_1), respectively. At 60-90 DAS period treatment C_3 (thiourea spray (1000 ppm)), reported higher LAR over rest of the treatments barring C_2 (salicylic acid spray (100 ppm)) during 2017-18 (24.60) and in pooled analysis (24.01), however, during 2018-19, again treatment C_2 (salicylic acid (100 ppm)), being at par with C_3 (thiourea spray (1000 ppm)) recorded significantly higher LAR (23.43) over no spray (C_0) and water spray (C_1). However, at 90 DAS-at harvest phase LAR did not show any significant variation during both the years and in pooled analysis due to foliar spray of stress mitigation bio-regulators.

Leaf area index (LAI)

Seed soaking: An examination of the data (Table 6.0) revealed that seed soaking differ significantly in their effect on LAI at 90 DAS during both the years and in pooled mean. Seed soaking with Salicylic acid (100 ppm) (S_2) observed significantly higher leaf area index during 2017-18 (2.492), 2018-19 (2.515) and in pooled data (2.504), representing an increase of 13.63 and 9.63 per cent over no seed soaking (S_0) and seed soaking with water spray (S_1) at 90 DAS in pooled analysis. Similar results were also reported by Yadav (2000) in oat, Solanki (2002) ^[16] in clusterbean, Arora (2004) ^[3] in

barley and Yadav (2005) ^[17] in wheat.

Foliar spray: Significantly higher leaf area index (LAI) during both the years of study and in pooled data, representing an increase of 11.71 and 9.25 per cent, 11.16 and 7.79 per cent, 11.43 and 8.52 per cent, respectively, over no foliar spray (C_0) and foliar spray with water spray (C_1) during at 90 days after sowing. Salicylic acid is one such plant growth regulators, which participate in the regulation of a number of physiological events taking place in the plant (Ashraf *et al.*, 2010) ^[4].

Table 5: Effect of seed soaking and foliar spray of stress mitigating bio-regulators on leaf area ratio (LAR) at different periodical of wheat

Treatments	Leaf area ratio(cm^2/g)								
	30-60 DAS			60-90 DAS			90 DAS-at harvest		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Seed soaking									
S_0 - Control (No seed soaking)	21.13	21.00	21.07	23.61	21.69	22.65	34.91	34.00	34.46
S_1 - Seed soaking with water	20.84	20.69	20.76	23.83	22.83	23.33	34.94	34.56	34.75
S_2 - Seed soaking with Salicylic acid (100 ppm)	21.69	21.91	21.80	24.56	24.69	24.62	35.42	34.62	35.02
S_3 - Seed soaking with Thiourea (500ppm)	22.08	21.89	21.98	24.22	24.36	24.29	34.99	34.56	34.77
S.Em+	0.33	0.35	0.24	0.23	0.37	0.22	0.46	0.48	0.33
CD (P = 0.05)	0.94	0.99	0.67	0.65	1.06	0.61	NS	NS	NS
Foliar spray									
C_0 -Control (No spray)	21.08	20.62	20.85	23.46	23.49	23.47	34.82	34.35	34.58
C_1 - Water spray	20.85	20.65	20.75	23.70	23.23	23.47	35.00	34.40	34.70
C_2 - Salicylic acid spray (100 ppm)	21.98	22.14	22.06	24.46	23.43	23.95	35.30	34.51	34.90
C_3 - Thiourea spray (1000 ppm)	21.83	22.08	21.96	24.60	23.42	24.01	35.15	34.48	34.82
S.Em+	0.33	0.35	0.24	0.23	0.37	0.22	0.46	0.48	0.33
CD (P = 0.05)	0.94	0.99	0.67	0.65	NS	0.61	NS	NS	NS
S x C, Y x S, Y x C, Y x S x C	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	6.18	6.54	6.36	3.78	6.37	5.20	5.26	5.58	5.42

Table 6: Effect of seed soaking and foliar spray of stress mitigating bio-regulators on leaf area index (LAI) at 90 DAS of wheat

Treatment	Leaf area Index		
	2017-18	2018-19	Pooled
Seed soaking			
S_0 - Control (No seed soaking)	2.193	2.215	2.204
S_1 - Seed soaking with water	2.273	2.295	2.284
S_2 - Seed soaking with Salicylic acid (100 ppm)	2.492	2.515	2.504
S_3 - Seed soaking with Thiourea (500ppm)	2.432	2.455	2.444
S.Em+	0.038	0.050	0.031
CD (P = 0.05)	0.107	0.143	0.088
Foliar spray			
C_0 -Control (No spray)	2.220	2.240	2.230
C_1 - Water spray	2.270	2.310	2.290
C_2 - Salicylic acid spray (100 ppm)	2.480	2.490	2.485
C_3 - Thiourea spray (1000 ppm)	2.420	2.440	2.430
S.Em+	0.038	0.050	0.031
CD (P = 0.05)	0.107	0.143	0.088
S x C, Y x S, Y x C, Y x S x C	NS	NS	NS
CV (%)	6.42	8.47	7.53

Net assimilation rate (NAR)

Seed soaking: A perusal of data (Table 7.0) revealed that seed soaking with salicylic acid (100 ppm) (S_2), remaining at par with seed soaking with thiourea (500 ppm) (S_3), recorded significantly higher NAR at 30-60 (2.807 and 2.783), 60-90 days (0.748 and 0.759) and 90 days-at harvest growth phases (0.380 and 0.301) for the year 2017-18 and on pooled basis, respectively over no seed soaking (S_0) and seed soaking with water (S_1). During 2018-19 a reverse trend was observed at 30-60 DAS and at 60-90 DAS wherein, treatment S_3 (seed soaking with thiourea (500 ppm)) enhanced NAR over rest of

the treatments barring S_2 (seed soaking with salicylic acid (100 ppm)), while at 90 DAS-harvest stages, seed soaking treatments did not exert any significant impact on NAR. On the basis of pooled mean, the seed soaking with salicylic acid (100 ppm) represented an increase of 4.47 and 2.73 per cent at 30-60 DAS phase, 4.69 and 2.99 per cent at 60-90 DAS, and 3.44 and 3.08 per cent at 90 days-at harvest over no seed soaking and seed soaking with water

Foliar spray: Foliar spray did not have any remarkable influence on NAR at 30-60 DAS and 60-90 DAS phase

during both the years and in pooled analysis. However, foliar spraying with salicylic acid (100 ppm) (C₂) recorded significantly higher NAR at 90 DAS-harvest stage over rest of the treatments barring C₃ (thiourea spray (1000 ppm))

treatment during both the years and pooled analysis. On the basis of pooled mean, salicylic acid spray (100 ppm) registered an increase of 8.16 and 3.39 per cent at 90 days-at harvest phase over control and water spray, respectively.

Table 7: Effect of seed soaking and foliar spray of stress mitigating bio-regulators on net assimilation rate (NAR) at different periodical of wheat

Treatments	Net assimilation rate(g/m ² leaf area/day)								
	30-60 DAS			60-90 DAS			90 DAS-at harvest		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Seed soaking									
S ₀ - Control (No seed soaking)	2.651	2.677	2.664	0.716	0.734	0.725	0.290	0.291	0.291
S ₁ - Seed soaking with water	2.692	2.725	2.709	0.734	0.740	0.737	0.294	0.290	0.292
S ₂ - Seed soaking with Salicylic acid (100 ppm)	2.807	2.759	2.783	0.748	0.770	0.759	0.308	0.294	0.301
S ₃ - Seed soaking with Thiourea (500ppm)	2.747	2.760	2.753	0.740	0.772	0.756	0.307	0.293	0.300
S.Em+	0.031	0.017	0.018	0.006	0.006	0.004	0.004	0.004	0.003
CD (P = 0.05)	0.089	0.049	0.050	0.017	0.017	0.012	0.012	NS	0.008
Foliar spray									
C ₀ -Control (No spray)	2.661	2.726	2.694	0.731	0.752	0.741	0.283	0.281	0.282
C ₁ - Water spray	2.716	2.723	2.720	0.737	0.754	0.745	0.294	0.296	0.295
C ₂ - Salicylic acid spray (100 ppm)	2.760	2.741	2.750	0.738	0.757	0.748	0.313	0.297	0.305
C ₃ - Thiourea spray (1000 ppm)	2.760	2.731	2.746	0.733	0.753	0.743	0.309	0.294	0.301
S.Em+	0.031	0.017	0.018	0.006	0.006	0.004	0.004	0.004	0.003
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	0.012	0.011	0.008
S x C, Y x S, Y x C, Y x S x C	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.60	2.51	3.70	3.27	3.18	3.23	5.75	5.15	5.47

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