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Mitigating terminal heat stress in wheat (*Triticum aestivum)* through foliar application of growth regulators: Effects on seed quality

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Abstract
The present study was undertaken to evaluate the effectiveness of foliar spray of various chemical treatments to mitigate the adverse effects of terminal heat stress on the seed quality of wheat (*Triticum aestivum* L.). The experiment was conducted in 2020-21 using two wheat varieties (K-9423 and K-607) and 22 foliar treatments including salicylic acid, ascorbic acid, potassium chloride, thiourea, and cycocel at different stages. Observations were recorded on 1000 seed weight, germination percentage, total seedling length, seedling dry weight, seedling vigour index-I and II. Among all treatments, salicylic acid @ 400 ppm applied at both vegetative and anthesis stages significantly improved seed quality parameters with highest values observed for variety K-607. The study concludes that salicylic acid at 400 ppm is effective in mitigating heat stress and improving seed quality in wheat.

Keywords: Wheat, terminal heat stress, salicylic acid, seed quality, seed vigour, foliar spray

Introduction
Wheat (*Triticum aestivum* L.), a staple food crop, is sensitive to temperature fluctuations during its reproductive stage. Terminal heat stress, common in the Indo-Gangetic plains, affects wheat yield and seed quality by shortening the grain filling period. Various foliar applications of plant growth regulators and antioxidants have been reported to enhance tolerance to heat stress. Salicylic acid, ascorbic acid, thiourea, potassium chloride, and cycocel have demonstrated positive physiological responses in stressed plants. This study was conducted to evaluate the effect of these chemical sprays on seed quality parameters under heat stress conditions.

Materials and Methods
The study was conducted during 2020-21 at the Seed Science and Technology laboratory, C.S. Azad University of Agriculture and Technology, Kanpur. Two wheat varieties (K-9423 and K-607) were evaluated under 22 foliar spray treatments including combinations of salicylic acid (400 and 800 ppm), ascorbic acid (10 ppm), KCl (1%), thiourea (400 ppm), and cycocel (400 and 800 ppm) applied at vegetative, anthesis, or both stages.
The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Seed quality parameters observed included:

i) **Germination (%):** Hundred seeds in three replications for different seed materials were tested for seed germinability. The seeds were spread on two moist towel papers kept over a butter paper. The e seeds were arranged in ten rows of ten seeds each with radicle end of seed oriented downwards. The seeds were then covered with another sheet of moist towel paper, rolled up along with butter paper and fastened with a rubber band. The rolled towel papers were placed in the germination room at 45-degree angle inclined position at temperature 20°C and 90% relative humidity. On the 8th day after the test, the paper towels were opened to record the germination.

The germinated seeds were evaluated into normal seedlings, abnormal seedlings, and dead seeds. Germination percentage was recorded based on normal seedlings only. The results have been statistically analyzed for presentation.

$$\text{Germination (\%)} = \frac{\text{Total number of seeds germinated}}{\text{Total No.of Seeds planted}} \times 100$$

ii) **M1000 seed weight (g):** A total of 1000 grains in each entry was taken and weighed in gram with the help of an electric balance.

iii) **Seedling length (cm):** Seedling length was calculated on 8th day after germination for measuring seedling length (cm) of the seedling on randomly selected 10 seedlings/ replication with the help of meter scale.

iv) **Seedling dry weight (g):** Ten normal seedlings used for measuring the seedlings length were put in the glass beaker and dried in hot air oven maintained at 84±10C temperature for 24 hours. Afier that the seedlings were removed and allowed to cool down in the desiccators for 30 minutes, the weighing was done in an electronic balance. The average dry weight in gm 1 for 10 seedlings was recorded.

v) **Seedling vigour index-I:** It is calculated by using the following formula, given by Abdul-Bakí and Anderson (1973).

Seed vigour index-I=germination percentage x seedling length (cm.)

vi) **Seedling vigour index-II**

Seed vigour index-II=germination percentage x seedling dry weight (g.)

Statistical Analysis: The data recorded on the above characters were subjected to statistical
analysis. The following procedure was used for the analysis of data obtained during experiment-

i) **Mean:** Mean is computed by dividíng the sum of all the observations in the sample by their number/frequencies.

Mean (X)=Σx/n

Where,
X=Mean
Σx=Summation of all observations (x) in the sample
N=Number of obsrvations in the sample.

ii) **Analysis of variance for field observations:** The analysis of variance was worked out to test the differences among genotypes by F-test. It was carried out according to the methodology advocated by Panse and Sukhatme (1967. ANOVA helps in partitioning the total variance into three components *viz*, replication, treatment and error.

Analysis of variance was done under the fixed effective model given below:

$Y_{ij}=\mu+gi+rj+eij$

Where,
μ=Overall mean.
Y_{ij}=Phenotypic observation in the i^{th} treatment and j^{th} replication.
$g_{i=}$effect of i^{th} treatment
$r_{j=}$effect of j^{th} replication
$e_{ij=}$random error associated with i^{th} treatment and j^{th} replication.
i=1,2,3, 4.....20.
J=1,2

Results

The results of the experiment showed significant differences among varieties, treatments, and their combinations for seed quality parameters. The detailed outcomes of each parameter are as follows:

1000 Seed Weight (g)

Significant variation was recorded in 1000 seed weight due to chemical spray treatments and variety differences. The highest 1000 seed weight (40.10 g) was recorded in Variety K-607 with the treatment T_{17} (Salicylic acid @ 400 ppm at vegetative + anthesis stage), followed by T_{16} and T_6. The control (T_1) recorded the lowest seed weight (35.50 g in V1).

Table 1: Treatments and Test weight (g)

Treatments		Test weight(g)		
	Stage of Spray	**V_1**	**V_2**	**Mean**
T_1	Control (without spray)	35.50	36.80	36.15
T_2	Salicylic acid spray at vegetative stage @ 800 ppm	35.50	37.83	36.67
T_3	Salicylic acid spray at vegetative stage @ 400 ppm	35.50	38.17	36.84
T_4	Ascorbic acid spray at vegetative stage @ 10 ppm	36.03	37.67	36.85
T_5	KCl spray at vegetative stage @ 1%	35.83	38.00	36.92
T_6	Thiourea spray at vegetative stage @ 400 ppm	36.80	39.20	38.00
T_7	Cycocel spray at vegetative stage @ 800 ppm	36.80	38.90	37.85
T_8	Cycocel spray at anthesis stage (@ 400 ppm	36.77	38.50	37.64
T_9	Salicylic acid spray at anthesis stage (@ 800 ppm	36.00	38.00	37.00
T_{10}	Salicylic acid spray at anthesis stage (@ 400 ppm	36.00	38.00	37.00
T_{11}	Ascorbic acid spray at anthesis stage (@ 10 ppm	36.00	39.00	37.50
T_{12}	KCl spray at anthesis stage (@ 1%	36.27	37.93	37.10
T_{13}	Thiourea spray at anthesis stage (@ 400 ppm	37.00	38.00	37.50
T_{14}	Cycocel spray at anthesis stage (@ 800 ppm	36.80	39.30	38.05
T_{15}	Cycocel spray at anthesis stage (@ 400 ppm	36.17	37.80	36.99
T_{16}	Salicylic acid spray at veg.+ anth. stage @ 800 ppm	37.70	39.30	38.50
T_{17}	Salicylic acid spray at veg.+ anth. stage @ 400 ppm	36.17	37.80	36.99
T_{18}	Ascorbic acid spray at veg.+ anth. stage @ 10 ppm	37.70	38.00	37.85

T_{19}	KCl spray at veg.+ anth. stage @ 1%	36.80	38.00	37.40
T_{20}	Thiourea spray at veg.+ anth. stage @ 400 ppm	36.60	38.50	37.55
T_{21}	Cycocel spray at veg.+ anth. stage @ 800 ppm	37.00	39.00	38.00
T_{22}	Cycocel spray at veg.+ anth. stage @ 400 ppm	37.70	39.00	37.44
	Mean	36.56	38.41	
		V	T	V×T
	C.D (p>0.05)	0.595	1.186	N/A
	S.E.(d)	0.129	0.595	0.842
	S.E.(m)	0.091	0.421	0.426

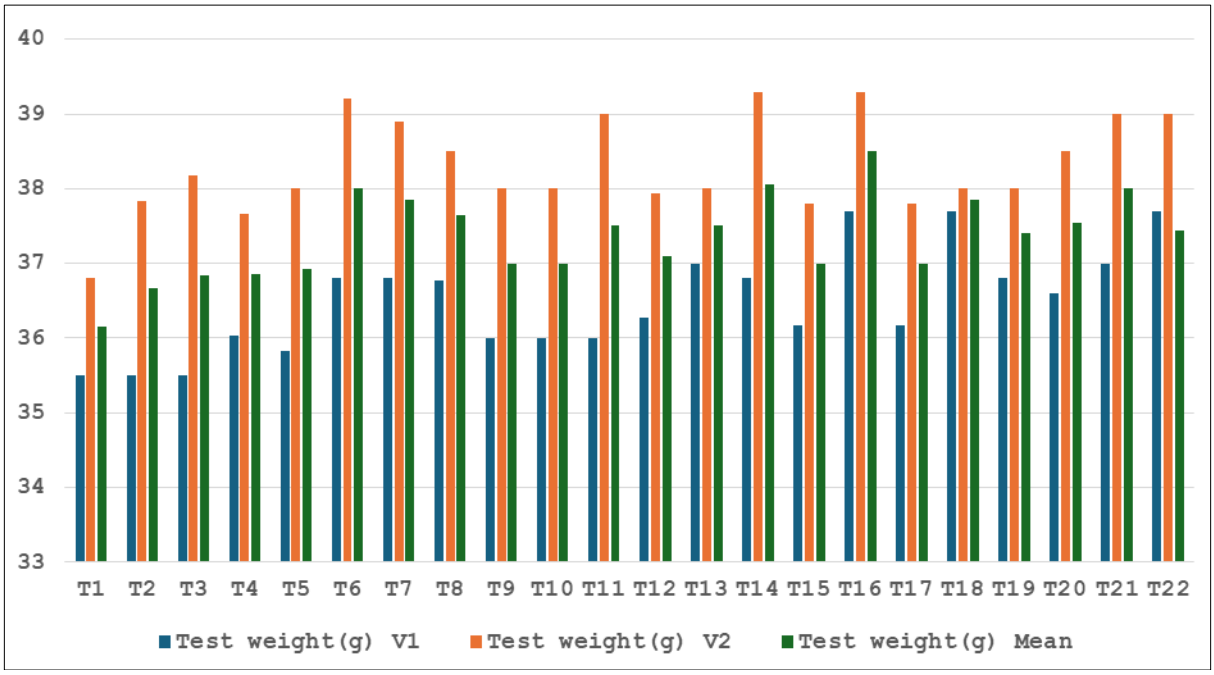

Fig 1: Effect of treatments on Test weight (g)

Germination Percentage (%)

Maximum germination (98.50%) was recorded in T_{17} for K-607, followed by T_{16} (92.20%) and T_{21} (91.00%). The lowest germination percentage (85.70%) was recorded in the control treatment (T_1, V1). Among all treatments, salicylic acid application showed the most positive effect on germination enhancement under terminal heat stress conditions.

Table 2: Treatments and Germination%

Treatments		**Germination%**		
	Stage of Spray	**V_1**	**V_2**	**Mean**
T_1	Control (without spray)	85.70	87.60	86.65
T_2	Salicylic acid spray at vegetative stage @ 800 ppm	87.33	89.23	88.28
T_3	Salicylic acid spray at vegetative stage @ 400 ppm	86.27	88.17	87.22
T_4	Ascorbic acid spray at vegetative stage @ 10 ppm	86.13	88.03	87.08
T_5	KCl spray at vegetative stage @ 1%	89.00	90.90	89.95
T_6	Thiourea spray at vegetative stage @ 400 ppm	89.30	91.20	90.25
T_7	Cycocel spray at vegetative stage @ 800 ppm	87.50	89.40	88.45
T_8	Cycocel spray at anthesis stage (@ 400 ppm	87.33	88.90	88.12
T_9	Salicylic acid spray at anthesis stage (@ 800 ppm	87.13	88.50	87.82
T_{10}	Salicylic acid spray at anthesis stage (@ 400 ppm	87.20	88.23	87.72
T_{11}	Ascorbic acid spray at anthesis stage (@ 10 ppm	88.00	90.00	89.00
T_{12}	KCl spray at anthesis stage (@ 1%	89.33	86.13	87.73
T_{13}	Thiourea spray at anthesis stage (@ 400 ppm	87.00	86.00	86.50
T_{14}	Cycocel spray at anthesis stage (@ 800 ppm	89.00	89.40	89.20
T_{15}	Cycocel spray at anthesis stage (400 ppm	88.60	88.60	88.60
T_{16}	Salicylic acid spray at veg.+ anth. stage @ 800 ppm	89.70	92.20	90.95
T_{17}	Salicylic acid spray at veg.+ anth. stage @ 400 ppm	87.60	98.50	93.05
T_{18}	Ascorbic acid spray at veg.+ anth. stage @ 10 ppm	88.20	88.00	88.10
T_{19}	KCl spray at veg.+ anth. stage 1%	88.27	86.27	87.27
T_{20}	Thiourea spray at veg.+ anth. stage @ 400 ppm	87.90	86.90	87.40
T_{21}	Cycocel spray at veg.+ anth. stage @ 800 ppm	91.00	89.00	90.00
T_{22}	Cycocel spray at veg.+ anth. stage @ 400 ppm	88.90	88.30	88.60
	Mean	88.02	89.07	

		V	T	V×T
	C.D (p>0.05)	N/A	1.92	N/A
	S.E.(d)	0.167	0.964	1.363
	S.E.(m)	0.118	0.681	0.554

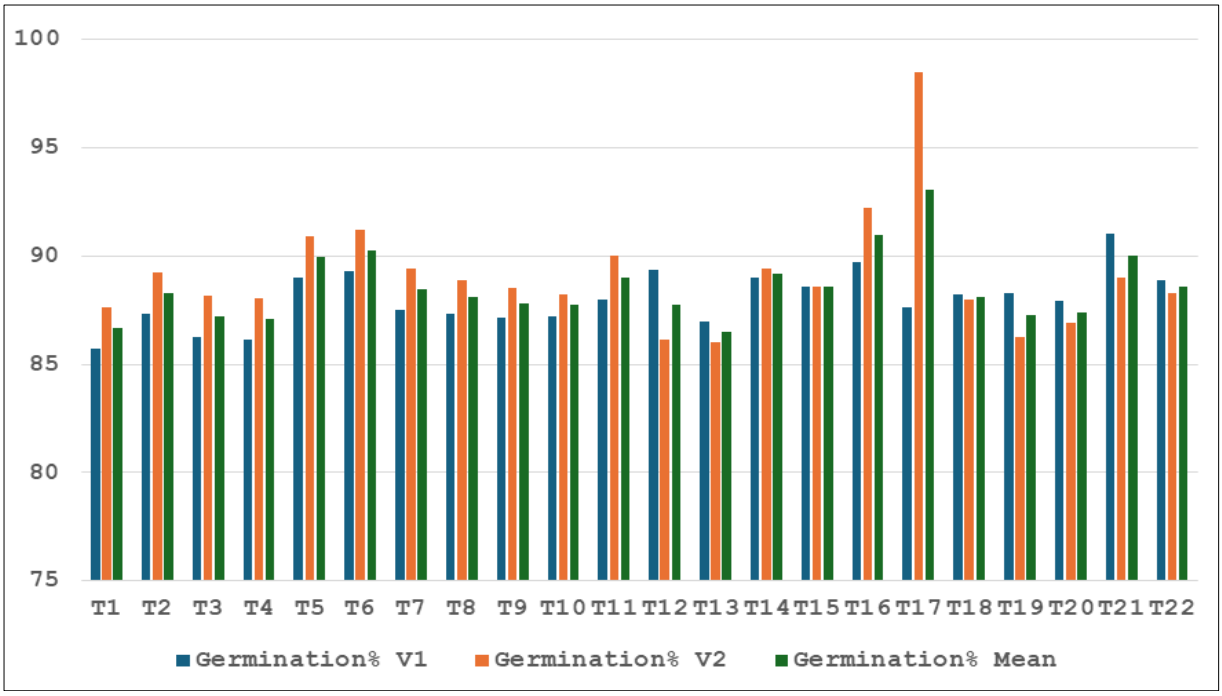

Fig 2: Effect of treatments on Germination %

Seedling Length (cm)

The data showed that T_{17} treatment (SA @ 400 ppm at both stages) produced the highest average seedling length (24.90 cm in K-607). Other effective treatments were T_{22}, T_{16}, and T6. Minimum seedling length (23.50 cm) was observed in the control treatment (T_1, V1).

Table 3: Treatments and Seedling length (cm)

Treatments		**Seedling length (cm)**		
	Stage of Spray	**V_1**	**V_2**	**Mean**
T_1	Control (without spray)	23.50	23.60	23.55
T_2	Salicylic acid spray at vegetative stage @ 800 ppm	23.83	23.57	23.70
T_3	Salicylic acid spray at vegetative stage @ 400 ppm	24.50	23.70	24.10
T_4	Ascorbic acid spray at vegetative stage @ 10 ppm	23.97	23.53	23.75
T_5	KCl spray at vegetative stage @ 1%	24.13	23.83	23.98
T_6	Thiourea spray at vegetative stage @ 400 ppm	24.10	24.00	24.05
T_7	Cycocel spray at vegetative stage @ 800 ppm	24.00	23.80	23.90
T_8	Cycocel spray at anthesis stage (@ 400 ppm	23.50	24.03	23.77
T_9	Salicylic acid spray at anthesis stage (@ 800 ppm	23.93	24.00	23.97
T_{10}	Salicylic acid spray at anthesis stage (@ 400 ppm	23.83	23.73	23.78
T_{11}	Ascorbic acid spray at anthesis stage (@ 10 ppm	24.00	24.00	24.00
T_{12}	KCl spray at anthesis stage (@ 1%	24.10	23.70	23.90
T_{13}	Thiourea spray at anthesis stage (@ 400 ppm	23.83	23.87	23.85
T_{14}	Cycocel spray at anthesis stage (@ 800 ppm	24.60	24.00	24.30
T_{15}	Cycocel spray at anthesis stage (@ 400 ppm	24.10	23.90	24.00
T_{16}	Salicylic acid spray at veg.+ anth. stage @ 800 ppm	24.00	24.00	24.00
T_{17}	Salicylic acid spray at veg.+ anth. stage @ 400 ppm	24.20	24.90	24.55
T_{18}	Ascorbic acid spray at veg.+ anth. stage @ 10 ppm	24.10	23.70	23.90
T_{19}	KCl spray at veg.+ anth. stage @ 1%	23.93	23.90	23.92
T_{20}	Thiourea spray at veg.+ anth. stage @ 400 ppm	24.10	24.00	24.05
T_{21}	Cycocel spray at veg.+ anth. stage @ 800 ppm	24.00	24.00	24.00
T_{22}	Cycocel spray at veg.+ anth. stage @ 400 ppm	24.40	24.70	24.55
	Mean	24.03	23.93	
		V	T	V×T
	C.D (p>0.05)	N/A	N/A	N/A
	S.E.(d)	0.048	0.300	0.424
	S.E.(m)	0.034	0.212	0.159

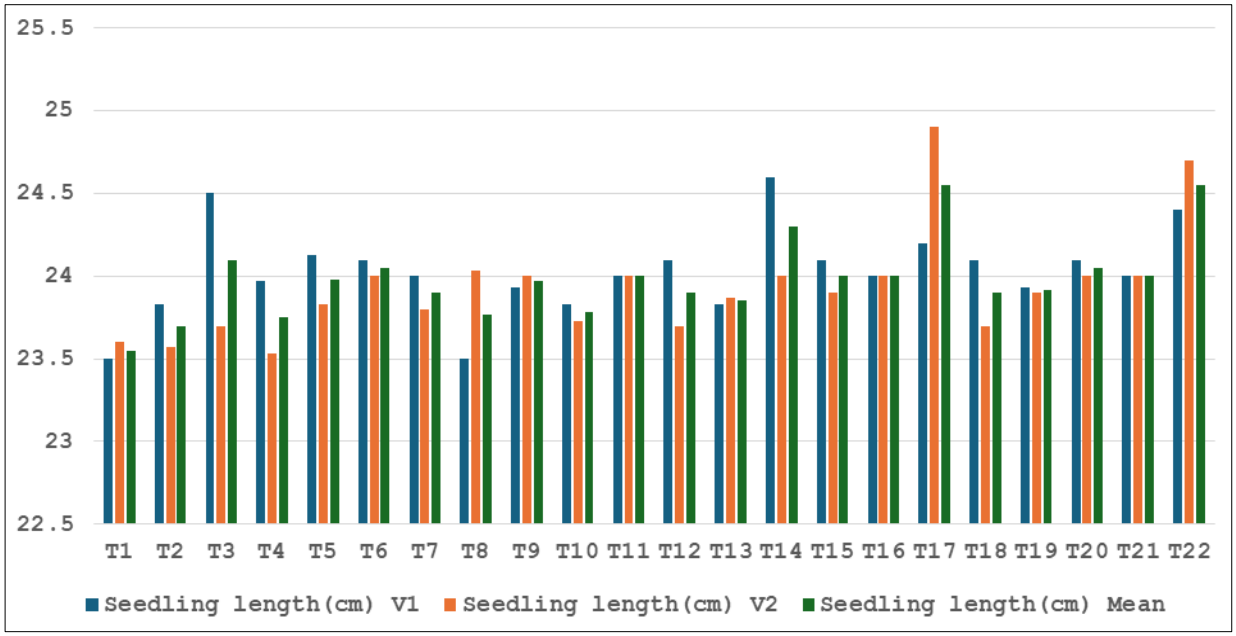

Fig 3: Effect of treatments on Total Seedling length(cm)

Seedling Dry Weight (g)

Maximum seedling dry weight (0.14 g) was noted in T_{17} and several other treatments such as T_6, T_{13}, T_{15}, T_{18}, and T_{20}. The control treatment (T_1) had the lowest seedling dry weight (0.10 g). This indicates the improved metabolic activity and photosynthate accumulation in primed seeds.

Table 4: Treatments and Seedling dry weight (g)

Treatments		Seedling dry weight (g)		
	Stage of Spray	**V_1**	**V_2**	**Mean**
T_1	Control (without spray)	0.10	0.10	0.10
T_2	Salicylic acid spray at vegetative stage @ 800 ppm	0.12	0.13	0.13
T_3	Salicylic acid spray at vegetative stage @ 400 ppm	0.12	0.13	0.13
T_4	Ascorbic acid spray at vegetative stage @ 10 ppm	0.12	0.13	0.13
T_5	KCl spray at vegetative stage @ 1%	0.12	0.12	0.12
T_6	Thiourea spray at vegetative stage @ 400 ppm	0.13	0.14	0.14
T_7	Cycocel spray at vegetative stage @ 800 ppm	0.13	0.13	0.13
T_8	Cycocel spray at anthesis stage (@ 400 ppm	0.13	0.13	0.13
T_9	Salicylic acid spray at anthesis stage (@ 800 ppm	0.12	0.14	0.13
T_{10}	Salicylic acid spray at anthesis stage (@ 400 ppm	0.10	0.10	0.10
T_{11}	Ascorbic acid spray at anthesis stage (@ 10 ppm	0.12	0.13	0.13
T_{12}	KCl spray at anthesis stage (@ 1%	0.12	0.14	0.13
T_{13}	Thiourea spray at anthesis stage (@ 400 ppm	0.13	0.14	0.14
T_{14}	Cycocel spray at anthesis stage (@ 800 ppm	0.12	0.14	0.13
T_{15}	Cycocel spray at anthesis stage (@ 400 ppm	0.13	0.14	0.14
T_{16}	Salicylic acid spray at veg.+ anth. stage @ 800 ppm	0.12	0.13	0.13
T_{17}	Salicylic acid spray at veg.+ anth. stage @ 400 ppm	0.13	0.14	0.14
T_{18}	Ascorbic acid spray at veg.+ anth. stage @ 10 ppm	0.13	0.14	0.14
T_{19}	KCl spray at veg.+ anth. stage @ 1%	0.12	0.14	0.13
T_{20}	Thiourea spray at veg.+ anth. stage @ 400 ppm	0.13	0.14	0.14
T_{21}	Cycocel spray at veg.+ anth. stage @ 800 ppm	0.10	0.10	0.10
T_{22}	Cycocel spray at veg.+ anth. stage @ 400 ppm	0.13	0.14	0.14
	Mean	O.12	0.13	
		V	T	V×T
	C.D (p>0.05)	0.005	0.008	N/A
	S.E.(d)	0.001	0.004	0.005
	S.E.(m)	0.001	0.003	0.004

Seedling Vigour Index-I

Seedling Vigour Index-I, calculated as germination % × seedling length, was highest (2294.6) in T_{17} (K-607), indicating robust growth under combined salicylic acid treatment. Other superior treatments included T_{16} (2236.8), T_{22} (2199.3), and T_{20} (2186.1). Control treatment showed the lowest SVI-I (1990.3 in V1).

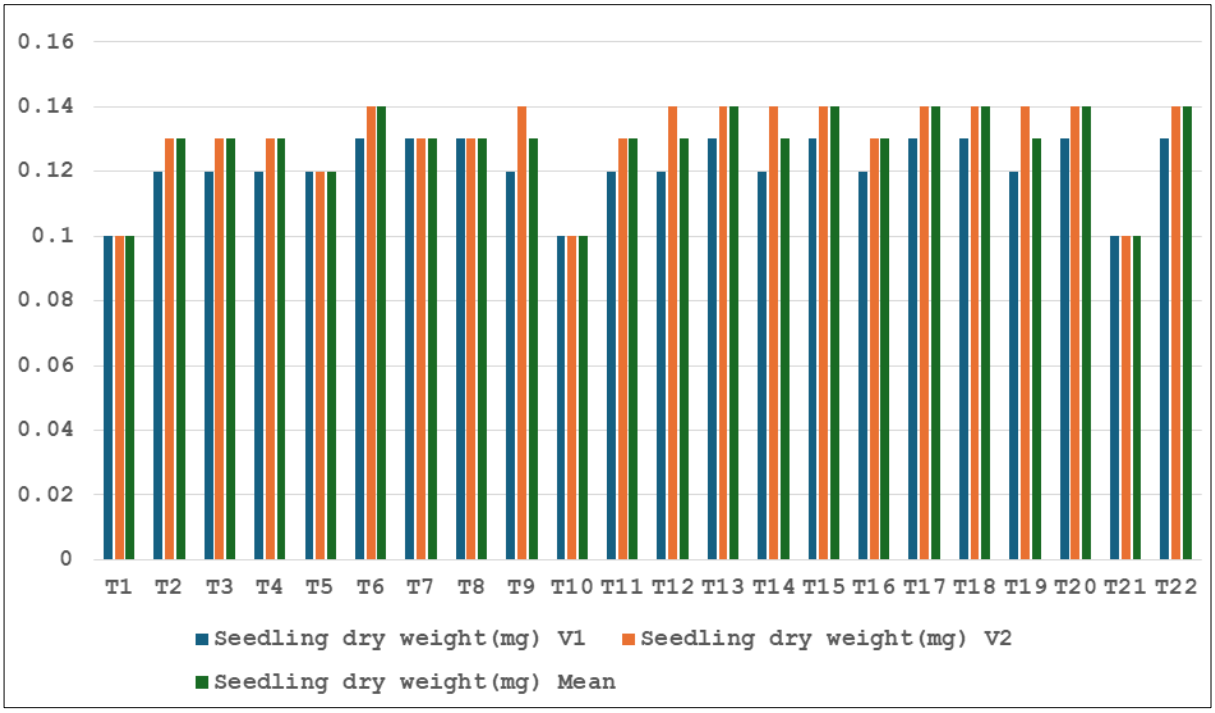

Fig 4: Effect of treatments on Seedling dry weight (mg)

Table 5: Treatments and Seed Vigour Index-I

Treatments		Seed Vigour Index-I		
	Stage of Spray	**V_1**	**V_2**	**Mean**
T_1	Control (without spray)	1990.3	1994.7	1992.5
T_2	Salicylic acid spray at vegetative stage @ 800 ppm	2098.7	2115.3	2107.0
T_3	Salicylic acid spray at vegetative stage @ 400 ppm	2131.3	2151.59	2141.4
T_4	Ascorbic acid spray at vegetative stage @ 10 ppm	2051.9	2026.4	2039.1
T_5	KCl spray at vegetative stage @ 1%	2063.8	2043.2	2053.5
T_6	Thiourea spray at vegetative stage @ 400 ppm	2113.3	2085.1	2099.2
T_7	Cycocel spray at vegetative stage @ 800 ppm	2092.6	2064.3	2078.5
T_8	Cycocel spray at anthesis stage (@ 400 ppm	2093.5	2062.7	2078.1
T_9	Salicylic acid spray at anthesis stage (@ 800 ppm	2113.7	2164.0	2138.9
T_{10}	Salicylic acid spray at anthesis stage (@ 400 ppm	2143.7	2145.9	2144.8
T_{11}	Ascorbic acid spray at anthesis stage (@ 10 ppm	2075.1	2047.2	2061.1
T_{12}	KCl spray at anthesis stage (@ 1%	2081.9	2055.0	2068.5
T_{13}	Thiourea spray at anthesis stage (@ 400 ppm	2157.0	2165.8	2161.4
T_{14}	Cycocel spray at anthesis stage (@ 800 ppm	2099.1	2080.7	2089.9
T_{15}	Cycocel spray at anthesis stage (@ 400 ppm	2125.8	2117.6	2121.7
T_{16}	Salicylic acid spray at veg.+ anth. stage @ 800 ppm	2185.5	2236.8	2211.1
T_{17}	Salicylic acid spray at veg.+ anth. stage @ 400 ppm	2233.9	2294.6	2264.2
T_{18}	Ascorbic acid spray at veg.+ anth. stage @ 10 ppm	2105.2	2093.2	2099.2
T_{19}	KCl spray at veg.+ anth. stage @ 1%	2130.3	2126.0	2128.1
T_{20}	Thiourea spray at veg.+ anth. stage @ 400 ppm	2168.3	2186.1	2177.2
T_{21}	Cycocel spray at veg.+ anth. stage @ 800 ppm	2150.5	2166.4	2158.4
T_{22}	Cycocel spray at veg.+ anth. stage @ 400 ppm	2165.9	2199.3	2182.6
	Mean	2116.9	2119.2	
		V	T	V×T
	C.D (p>0.05)	19.887	65.959	N/A
	S.E.(d)	9.990	33.133	46.857
	S.E.(m)	7.064	23.429	33.133

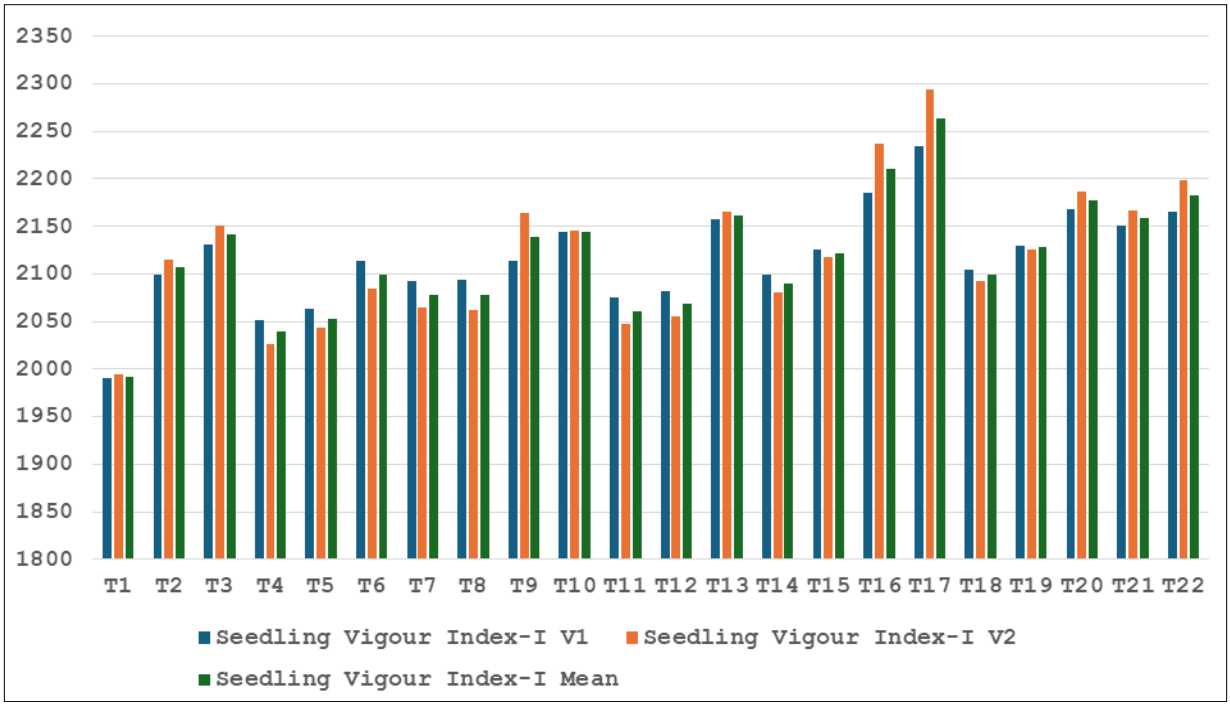

Fig 5: Effect of treatments on Seedling Vigour Index-I

Seedling Vigour Index-II

Seedling Vigour Index-II, calculated as germination % × seedling dry weight, followed a similar trend as SVI-I. Maximum value (13.53) was recorded in T_{17} (K-607), followed by T_{16} (12.61), T_{22} (12.53), and T_{15} (12.05). The control (T_1) again had the lowest SVI-II value (10.19).

Table 6: Treatments and Seedling Vigour Index-II

Treatments		Seedling Vigour Index-II		
	Stage of Spray	**V_1**	**V_2**	**Mean**
T_1	Control (without spray)	10.19	10.63	10.41
T_2	Salicylic acid spray at vegetative stage @ 800 ppm	10.89	11.63	11.26
T_3	Salicylic acid spray at vegetative stage @ 400 ppm	11.20	12.15	11.67
T_4	Ascorbic acid spray at vegetative stage @ 10 ppm	10.38	10.98	10.68
T_5	KCl spray at vegetative stage @ 1%	10.43	11.50	10.97
T_6	Thiourea spray at vegetative stage @ 400 ppm	10.89	1198	11.43
T_7	Cycocel spray at vegetative stage @ 800 ppm	10.74	11.64	11.19
T_8	Cycocel spray at anthesis stage (@ 400 ppm	10.79	11.67	11.23
T_9	Salicylic acid spray at anthesis stage (@ 800 ppm	10.98	12.21	11.60
T_{10}	Salicylic acid spray at anthesis stage (@ 400 ppm	11.47	12.22	11.84
T_{11}	Ascorbic acid spray at anthesis stage (@ 10 ppm	10.54	11.45	10.99
T_{12}	KCl spray at anthesis stage (@ 1%	10.62	11.61	11.11
T_{13}	Thiourea spray at anthesis stage (@ 400 ppm	11.06	12.01	11.54
T_{14}	Cycocel spray at anthesis stage (@ 800 ppm	10.81	11.85	11.33
T_{15}	Cycocel spray at anthesis stage (@ 400 ppm	11.04	12.05	11.54
T_{16}	Salicylic acid spray at veg.+ anth. stage @ 800 ppm	11.96	12.61	12.28
T_{17}	Salicylic acid spray at veg.+ anth. stage @ 400 ppm	12.86	13.53	13.19
T_{18}	Ascorbic acid spray at veg.+ anth. stage @ 10 ppm	11.12	12.01	11.56
T_{19}	KCl spray at veg.+ anth. stage @ 1%	11.64	12.17	11.95
T_{20}	Thiourea spray at veg.+ anth. stage @ 400 ppm	11.64	12.18	11.99
T_{21}	Cycocel spray at veg.+ anth. stage @ 800 ppm	11.56	12.07	11.39
T_{22}	Cycocel spray at veg.+ anth. stage @ 400 ppm	11.69	12.53	12.11
	Mean	11.11	11.94	
		V	T	V×T
	C.D ($p \geq 0.05$)	0.219	0.728	N/A
	S.E.(d)	0.110	0.366	2.517
	S.E.(m)	0.078	0.259	0.366

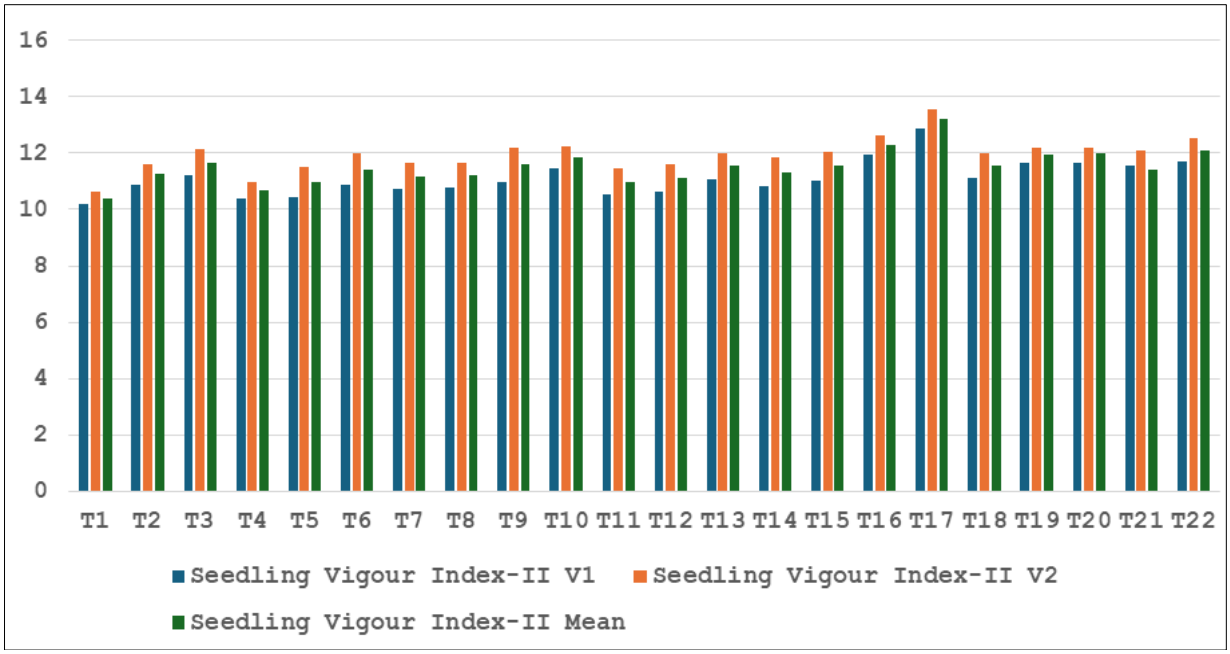

Fig 6: Effect of Treatments on Seedling Vigour Index-II

Discussion

The findings of this study clearly indicate that chemical spray treatments significantly improved seed quality traits in wheat under terminal heat stress conditions, particularly in variety K-607. These results align with earlier studies indicating that exogenous application of certain growth regulators and antioxidants enhances seed germination, seedling vigour, and seed weight under stress conditions.

Among the treatments, salicylic acid @ 400 ppm applied at both vegetative and anthesis stages (T_{17}) was the most effective across all measured parameters. Salicylic acid is a known signalling molecule that activates several physiological and biochemical mechanisms in plants, including antioxidant defense, ion transport, photosynthesis regulation, and osmotic balance, helping to mitigate abiotic stress effects like terminal heat stress [1-3]. Studies by Kousar *et al*. (2018) [2] and Khan *et al*. (2013) [4] reported similar enhancements in seed quality attributes following salicylic acid application under heat stress conditions [2, 4].

The superiority of K-607 over K-9423 may be due to its genetic potential for stress tolerance and higher responsiveness to foliar spray treatments. Similar varietal responses to stress mitigation were noted by Das *et al*. (2020) in mustard, where improved seed quality was recorded with bioregulator treatments [5].

Apart from salicylic acid, foliar sprays of thiourea, ascorbic acid, and cycocel also improved seed quality parameters. Thiourea likely contributed by enhancing enzymatic activity and antioxidant metabolism that reduce oxidative damage caused by high temperatures [6]. Ascorbic acid, being a major non-enzymatic antioxidant, improves redox homeostasis and chloroplast stability, aiding in seedling growth and survival [7]. Cycocel (CCC), a plant growth regulator, reduces vegetative growth and redirects assimilates toward reproductive structures, improving seed weight and seedling vigour [8, 9].

Although the variety × treatment interaction was statistically non-significant, the best seed quality values were consistently recorded in K-607 treated with T_{17}, suggesting this combination as highly effective. The findings are consistent with Hassanein *et al*. (2015) and Asthir *et al*. (2015) who also documented the positive role of salicylic acid and thiourea under high temperature stress on wheat [10, 11].

Conclusion

Foliar spray of salicylic acid @ 400 ppm at vegetative and anthesis stages was found to be the most effective in mitigating terminal heat stress, enhancing seed quality attributes including test weight, germination, seedling vigour, and dry weight. Wheat variety K-607 consistently outperformed K-9423. Hence, salicylic acid @ 400 ppm can be recommended for field application to improve wheat seed quality under terminal heat stress.

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