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Seed Priming with Antioxidants to Improve Physiological Parameters in Sunflower cv. Co-2 under Unfavourable Germination Conditions

ASHWINI SAKPAL[1] AND A. SABIR AHAMED[2]
[1]Department of Seed Science and Technology, Agriculture College and Research Institute, Madurai - 625 104
[2]Department of Vegetable Science, Horticultural College & Research Institute for Women, Trichy - 620 027
e-Mail : ash.mduseed93@gmail.com

AUTHORS CONTRIBUTION

ASHWINI SAKPAL : Conceptualization, investigation and manuscript preparation;
SABIR AHAMED : Designing and editing

Corresponding Author :
ASHWINI SAKPAL : Department of Seed Science and Technology, Agriculture College and Research Institute, Madurai

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ABSTRACT

Seeds priming is a frequently used technique to hasten germination and improve crop uniformity, particularly in unfavourable conditions. The effects of seed priming with four different antioxidants at two different concentrations under three unfavourable germination circumstances in sunflower were examined. The purpose of the study was to ascertain how antioxidants affects on physiological parameters in sunflower seed under favourable and various unfavourable germination conditions. The findings revealed that among the different conditions, seed germination was affected more at 40 °C. Thus the effect of heat stress was found to be minimized by seed priming with Butylated hydroxytoluene at 0.1 per cent followed by Butylatedhydroxy toluene at 2 per cent by recording 7 and 4 per cent higher germination over control. The seedling growth parameters such as root and shoot length, seedling dry matter production and vigour indices were influenced negatively by NaCl at 0.1 per cent stress condition. Under unfavourable germination conditions, seed priming with Butylated Hydroxy-toluene (BHT) at 0.1 per cent, followed by a- Tocopherol at 0.5 per cent and Ascorbic acid at 1.0 per cent, to improved seedling growth characteristics in sunflower.

Keywords : Sunflower, Antioxidants, Seed priming, Butylated hydroxytoluene, Seed germination and Seedling vigour

IN India, sunflower (*Helianthus annuus* L.) is a widely used oilseed crop. It is utilized as a raw material for agriculture-based industries and as a source of edible oil. The seed has 45-50 per cent high-quality oil content. Crop development depends on the use of high-quality seeds. Almost invariably, rapid and uniform emergence serves as the foundation for crop stand establishment. The original seed's quality, vigour and preservation methods all affect how long it will last in its pure form. Oil seeds are quite delicate because of the harsh weather conditions. It is hypothesised that their oil content easily oxidises, degrading the seeds while they are in storage (Wilson and Mc Donald, 1986).

In ancient days, various seed treatments were practised as initial production techniques for improved productivity. Seed invigoration is one programming strategy to raise crop productivity (Farooq *et al.,* 2006). Other methods of reviving seeds include hydropriming, hormonal priming, matrix-priming, hardening, osmo hardening, osmo conditioning and others (Windauer *et al.,* 2007).

Seed priming is one of the physiological methods, which improves seed performance and provides faster and more synchronized germination. Priming is frequently used to hasten germination and promote uniformity of different crops, especially in difficult emerging conditions (McDonald, 2000 and Halmer, 2004). The percentage of seeds that germinate under varied ecological conditions is affected by seed priming and it also affects the germination rate, seed vigour and seedling development.

In general, under unfavourable environmental conditions, this method has become a standard seed treatment that can raise the percentage and regularity of germination or seedling emergence (Halmer, 2004). Primed seeds may show quicker rates of germination, more uniform emergence, increased tolerance to environmental stress and less dormancy in many species after being rehydrated (Khan, 1992). Finding suitable priming agent (s) that could be utilised to boost plant's tolerance to challenging field conditions is therefore of great interest to the seed business (Job *et al.,* 1997).

Behairy *et al.* (2012) observed that sunflower seeds primed with antioxidants increased germination and seedling shoot length under salt stress as compared with untreated seeds. In sunflower, seed priming with antioxidants has beneficial effects on germination even at lower temperatures (Bailly *et al.,* 2000). Seed priming with the solution of antioxidant substances performed prior to accelerated ageing had a positive effect on the length of both roots and shoots (Draganic and Lekic, 2012). The aim of this study was to observe whether priming with an aqueous solution of antioxidants has an effect on sunflower seed performance under unfavourable germination conditions.

Material and Methods

Experimental Materials

Pure seeds of sunflower cv. Co-2, to understand the physiological mechanisms of adaptation to different stress during seed germination were collected from the Department of Oilseeds, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore which formed the base material for the study. Uniform sized seeds were selected. The sunflower hybrid Co-2 seeds were primed with different antioxidant solutions for 12 hrs. T_1-α-Tocopherol 0.5 per cent, T_2-α-Tocopherol 1.0 per cent, T_3-Ascorbic acid 0.5 per cent, T_4-Ascorbic acid 1.0 per cent, T_5-Glutathione 0.05 per cent, T_6-Glutathione 0.1 per cent, T_7-Butylated hydroxytoluene 0.1 per cent, T_8-Butylated hydroxytoluene 0.2 per cent, T_9-Control. After the expiry of soaking duration, the seeds were dried back to their original moisture content and tested for various seed quality parameters. Thus, all 9 treatments were considered as a factor (1). Primed seeds were subjected to three unfavourable germination conditions along with favourable germination conditions as the trials for germination conditions were conducted in four sets of temperatures with relative humidities. C_1-25 ± 2 °C and 95 ± 3 per cent RH, C_2-40 °C and 100 per cent RH, C_3-15 °C and 100 per cent RH, C_4-Pre-moistened media with NaCl 0.1 per cent solution + 25 ± 2 °C and 95 ± 3 per cent RH. Thus the 4 conditions considered as sub factor (2). Optimal conditions with respect to light and moisture were maintained for proper germination and development of seedlings. The physiological parameters were measured to evaluate the response of Co-2 cultivar to high temperature stress.

The details of each observation recorded in three replications have been given below:

Germination (%) (ISTA, 2020)

The germination test was conducted with 4 x100 seeds each using a between paper medium. The germination set-up has been placed in a germination room maintained at 25 ± 2 °C and 95 ± 3 per cent. At the end of 10 days of the germination period recommended as per ISTA (2020), the seedlings were evaluated. Based on the mean number of normal seedlings developed, the mean germination was expressed in percentage.

Abnormal Seedling per cent

The seedlings were evaluated based on the mean number of abnormal seedlings developed out of the total number of seeds put for germination. The mean abnormal seedlings were expressed in per cent.

Root Length (cm)

Ten normal seedlings were selected at random from each replication and the length of the root was measured from the collar region to the tip of the primary root and the mean was expressed in centimeter

Shoot Length (cm)

Ten normal seedlings were selected at random from each replication and the distance between the collar regions to the tip of the primary leaf was measured and the mean was expressed in centimeter.

Total Seedling Length (cm)

On the day of the final count, 10 normal seedlings were randomly selected from the germination test. The length between the collar region and the tip of the primary shoot was measured as the shoot length, and the length between the collar region and tip of the primary root was measured as the root length. The total seedling length (TSL) was calculated by adding the shoot and root lengths together (ISTA, 2020) and the average seedling length for each genotype in all replications and treatment combinations was recorded. The values of TSL were used for calculations of seedling vigour index (SVI) -I.

Seedling Dry Matter Production (10 seedlings g^{-1})

After measuring the root and shoot length, the ten normal seedlings in each replication were shade dried for 24 h and then in a hot air oven maintained at 70 ± 1 °C for 48 h. Then, they were cooled for 30 min in a desiccator which contained calcium chloride and then weighed in an electronic balance. The mean weight was expressed as dry matter production of 10 seedlings in gram.

Vigour Index I

On the day of the final count, 10 normal seedlings were randomly selected from the germination test. The length between the collar region and the tip of the primary shoot was measured as the shoot length, and the length between the collar region and tip of the primary root was measured as the root length. The total seedling length (TSL) was calculated by adding the shoot and root lengths together and used for estimation of vigour index I

The vigour index (VI) was computed using the following formula and expressed as a whole number (Abdul-Baki and Anderson, 1973).

Vigour index I = Germination percentage × Total seedling length (cm)

Vigour index II

The vigour index was computed by using the following formula and expressed in whole numbers (Abdul-Baki and Anderson, 1973).

Vigour index II = Germination (%) x dry weight of 10 seedlings.

Experimental Design and Statistical Analyses

The data of the experiment were collected and arranged in a factorial completely randomized design with nine levels of factor 1 (Treatments) and four levels of factor 2 (Germination conditions). Three replications for all the treatment combinations were applied in which 100 seeds per replication were used. Analysis of variance (ANOVA) from the data was employed to compute variable effects in both the factors and their interaction. Significant differences between means of treatments, germination conditions, and interactions were calculated using the least significant difference and compared with the means exercising Tukey's test at $P \leq 0.05$.

RESULTS AND DISCUSSION

Effect of Priming Treatments

Seed priming with antioxidants treatments showed a significant influence on germination as well as on abnormal seedling per cent. Among the treatments, (T_7) Butylated hydroxyl toluene 0.1 per cent recorded the highest germination of (79%) and minimum abnormal seedling (19%) followed by (T_5) Glutathione 0.05 per cent with (78%) germination and (20%) abnormal seedlings. Minimum germination (71%) and maximum abnormal seedlings (25%) were observed in control (T_9) (Table 1 and 2). Similar findings were reported by Ghassemi-golezani *et al.* (2008) in lentil.

A significant variation in shoot length and root length was observed due to seed priming treatments. A longer root was measured when the seeds were

TABLE 1

Effect of seed priming with antioxidants on germination (%) and abnormal seedling (%) under favourable and unfavourable germination conditions in sunflower cv. Co-2

Treatments (T)	Germination conditions (C)			
	(C_1) 25±2 °C and 95±3% RH	(C_2) 40 °C and 100% RH	(C_3) 15 °C and 100% RH	(C_4) NaCl 0.1%
T_1 - α-Tocopherol 0.5%	80 (63.44)	72 (58.05)	71 (57.42)	73 (58.70)
T_2 - α-Tocopherol 0.1%	82 (64.90)	75 (60.00)	78 (62.03)	74 (59.34)
T_3 - Ascorbic acid 0.5%	78 (62.03)	70 (56.79)	70 (56.79)	71 (57.42)
T_4 - Ascorbic acid1.0%	81 (64.16)	76 (60.67)	73 (58.70)	74 (59.34)
T_5 - Glutathione 0.05%	84 (66.42)	68 (55.55)	82 (64.90)	77 (61.34)
T_6 - Glutathione 0.1%	83 (65.65)	65 (53.73)	80 (63.44)	76 (60.67)
T_7 - Butylated hydroxy toluene 0.1%	85 (67.22)	79 (62.73)	74 (59.34)	78 (62.03)
T_8 - Butylated hydroxy toluene 0.2%	81 (64.16)	76 (60.67)	78 (62.03)	75 (60.00)
T_9 - Control	79 (62.73)	67 (54.94)	69 (56.17)	68 (55.55)
Mean	81 (64.16)	72 (58.05)	75 (60.00)	74 (59.34)
CD (P=0.05)	T = 0.81 **	C = 0.54 **	T x C = 1.62 **	

(* and ** represented the differences were significant at the 5 and 1 % levels and values in parentheses are arc sine transformed values)

TABLE 2

Effect of seed priming with antioxidants on abnormal seedling (%) under favourable and unfavourable germination conditions in sunflower cv. Co-2

Treatments (T)	Germination conditions (C)			
	(C_1) 25±2 °C and 95±3% RH	(C_2) 40 °C and 100% RH	(C_3) 15 °C and 100% RH	(C_4) NaCl 0.1%
T_1 - α-Tocopherol 0.5%	20 (26.57)	24 (29.33)	29 (32.58)	23 (28.66)
T_2 - α-Tocopherol 0.1%	18 (25.10)	19 (25.84)	22 (27.97)	22 (27.97)
T_3 - Ascorbic acid 0.5%	22 (27.97)	26 (30.66)	30 (33.21)	26 (30.66)
T_4 - Ascorbic acid1.0%	19 (25.84)	20 (26.57)	27 (31.31)	22 (27.97)
T_5 - Glutathione 0.05%	16 (23.58)	28 (31.95)	18 (25.10)	19 (25.84)
T_6 - Glutathione 0.1%	17 (24.35)	31 (33.83)	20 (26.57)	20 (26.57)
T_7 - Butylated hydroxy toluene 0.1%	15 (22.79)	17 (24.35)	26 (30.66)	18 (25.10)
T_8 - Butylated hydroxy toluene 0.2%	19 (25.84)	20 (26.57)	22 (27.97)	25 (30.00)
T_9 - Control	17 (24.35)	25 (30.00)	31 (33.83)	27 (29.33)
Mean	18 (25.10)	23 (28.66)	25 (30.00)	22 (27.97)
CD (P=0.05)	T = 0.28 **	C = 0.18 **	T x C = 0.56 **	

(* and ** represented the differences were significant at the 5 and 1 % levels and values in parentheses are arc sine transformed values) primed with (T_1) α-Tocopherol 0.5 per cent up to 30.5 cm while, (T_9) control seeds measured the shortest root of 26.3 cm. The longest shoot was recorded in the seeds primed with (T_7) Butylated hydroxy toluene 0.1 per cent of 20.7 cm followed by (T_1) α-Tocopherol 0.5 per cent (20.1cm) and (T_5) Glutathione 0.05 per cent (19.9cm) shoot length when compared to (T_9) control with only 17.9 cm (Table 3). Similarly, the result obtained by Draganic *et al*. (2012) notified that seed priming with different combinations of antioxidants resulted in an increase in root length over the control in medium vigour seeds.

Seedling dry matter production was significantly influenced by priming treatments. Among the treatments, irrespective of germination conditions provided, (T_7) Butylated hydroxy toluene 0.1 per cent recorded the maximum seedling dry matter production (0.324 g 10 seedlings^{-1}) which was on par with (T_2) α-Tocopherol 1 per cent (0.318 g 10 seedlings $^{-1}$). Whereas, (T_9) control recorded minimum seedling dry matter production with only 0.293 g 10 seedlings^{-1} (Table 4). Similar findings were reported by Pandita and Nagarajan (2000) in tomato. The results of vigour indices for priming treatment. Irrespective of germination conditions provided, (T_7) Butylated hydroxytoluene 0.1 per cent recorded the highest vigour index I (3995) and vigour index II (25.7) when compared to control (T_9) with only 3156 vigour index I and 20.8 vigour index II.

Effect of Germination Conditions

Researchers have emphasized that seed priming mitigates the adverse effects of different stress factors (Chiu *et al*., 1995). Hence, present studies were undertaken to assess the physiological performance of sunflower seeds under favourable and different unfavourable germination conditions.

The difference in germination (%) and abnormal seedling (%) was statistically significant due to germination conditions. Among the germination conditions, (C_2) 40 °C + 100 per cent RH exerted more stress on germinating seeds by recording only 72 per cent when compared to the favourable condition of (C_1) 25±2 °C + 95±3 per cent RH with 81 per cent germination. Whereas, maximum abnormal seedlings were recorded in (C_3) at 15 °C + 100 per cent RH (25%) due to the impact of stress on germinating seeds when compared to favourable condition of (C_1) 25±2 °C + 95±3 per cent RH with only 18 per cent (Table 1). The unfavourable germination condition that exerted a minimum effect on the germination was (C_4) NaCl 0.1 per cent with less abnormal seedling at 22 per cent (Table 1 and 2).

The unfavourable germination condition that exerted a minimum impact on the germination was (C_3) 15 °C + 100 per cent RH with 75 per cent germination and in the case of abnormal seedlings, it was in (C_4) NaCl 0.1 per cent *i.e*., 22 per cent when compared to normal favourable condition (C_1). A significant variation in shoot length and root length was observed due to germination conditions Among the stress conditions, (C_4) NaCl 0.1 per cent exerted more stress on root length by recording only 27.1 cm when compared to the favourable condition of (C_1) 25±2 °C and 95±3 per cent RH with (30.3cm). Among different unfavourable germination conditions, more reduction in shoot length was observed in (C_4) NaCl 0.1 per cent by recording only 17.6 cm when compared to the favourable condition of (C_1) 25±2 °C and 95±3 per cent RH with 20.7cm (Table 3). Numerous researchers have established that seed priming with an osmotic solution, especially under suboptimal temperature conditions, stimulates seed germination of sunflower (Smok *et al*., 1993), maize, wheat, barley, soyabean (Bodsworth and Bewley, 1981) and sweet maize.

Seedling dry matter production was significantly influenced by germination conditions. Among the germination conditions, (C_4) NaCl 0.1 per cent showed a reduction in seedling dry matter production with 0.284 g 10 seedlings^{-1}. Whereas, a favourable condition of (C_1) 25±2 °C and 95±3 per cent RH recorded 0.344 g 10 seedlings^{-1}. The unfavourable germination condition exerted minimum influence on the dry weight of seedlings was (C_2) 40 °C and 100 per cent RH with 0.323 g 10 seedlings^{-1} with a reduction of 6 per cent than normal

TABLE 3

Effect of seed priming with antioxidants on seedling root and shoot length (cm) under favourable and unfavourable germination conditions in sunflower cv. Co-2

Treatments (T)	Germination conditions (C)							
	Root length (cm)				Shoot length (cm)			
	(C_1) 25±2°C and 95±3% RH	(C_2) 40°C and 100% RH	(C_3) 15°C and 100% RH	(C_4) NaCl 0.1%	(C_1) 25±2°C and 95±3% RH	(C_2) 40°C and 100% RH	(C_3) 15°C and 100% RH	(C_4) NaCl 0.1%
T_1 - α-Tocopherol 0.5%	32.3	31	29.8	28.7	21.5	20.8	19.5	18.6
T_2 - α-Tocopherol 0.1%	28.7	27.6	26.8	25.3	20.5	19.9	18.5	17.7
T_3 - Ascorbic acid 0.5%	30.8	29.7	28.3	27.4	20.8	20	18.8	17.9
T_4 - Ascorbic acid1.0%	31.7	30.6	29.2	28.1	19.6	19.4	17.6	16.5
T_5 - Glutathione 0.05%	30.9	29.8	28.4	27.5	21.2	20.7	19.2	18.3
T_6 - Glutathione 0.1%	31.2	30.3	28.7	27.8	20.7	20.4	18.7	17.6
T_7 - BHT 0.1%	31.5	30.7	29	28.1	22	21.5	20	19.1
T_8 - BHT 0.2%	28.4	27.5	25.9	25.8	20.2	19.5	17.8	16.8
T_9 - Control	27.4	25.8	24.6	23.6	19.8	18.8	16.6	15.6
Mean	30.3	29.2	27.8	26.9	20.7	20.1	18.5	17.6
CD (P=0.05)	T=0.35 **	C=0.23 **	NS	-	T=0.25 **	C=0.17 **	TxC=0.51 *	-

(* and ** represented the differences were significant at the 5 and 1 % levels)

favourable condition (C_1) (Table 4). It may be due to the greater susceptibility of primed seeds to stress is related to the effect of priming and drying on the protection mechanisms encompassing free radical and peroxide-scavenging enzymes, such as superoxide dismutase, catalase and glutathione reductase (Chojnowski *et al*., 1997). It was the same as previous studies carried out by Chhetri *et al*. (1993) in french beans, peas, lentils, and millet and Draganic (2012) in sunflower.

The results of vigour indices for germination conditions. Among the germination conditions, (C_4) NaCl 0.1 per cent also showed the highest impact of stress on germinating seeds by recording only 3306 vigour index I and vigour index II by recording only (21) when compared to the favourable condition of (C_1) 25±2 °C and 95±3 per cent RH with 4157 vigour index I and vigour index II (28) (Fig.1 and 2). The saline condition showed a reduction in physiological parameters in canola, and it was observed by Hemmat katab (2007).

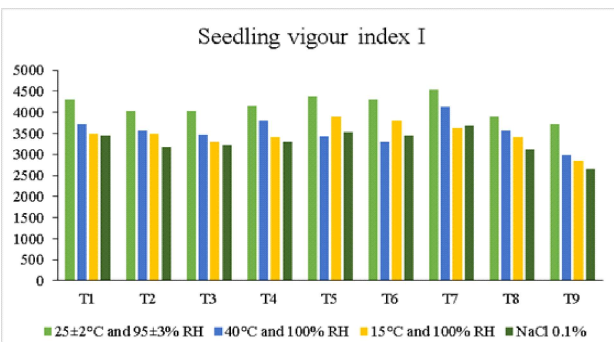
Interaction Effect of Priming Treatments and Germination Conditions

From the interaction effect, it was observed that seed primed using (T_5) Glutathione 0.05 per cent observed the highest germination (82%), which was 15.85 per cent more over the control seed under (C_3) 15 °C + 100 per cent RH whereas, the seed primed with (T_7) Butylated hydroxy toluene 0.1 per cent observed minimum abnormal seedling per cent 17 per cent. Whereas, (T_6) Glutathione 0.1 per cent recorded the highest abnormal seedling per cent 31 per cent under (C_2) 40˚C and 100 % RH (Table 1 and 2). However, the interaction between priming treatments and germination conditions was found to be non-significant for root length but significant for shoot length, hence highest shoot length of 21.5 cm was obtained when seeds primed with (T_7)

TABLE 4

Effect of seed priming with antioxidants on seedling dry matter production (10 seedlings g^{-1}) under favourable and unfavourable germination conditions in sunflower cv. Co-2

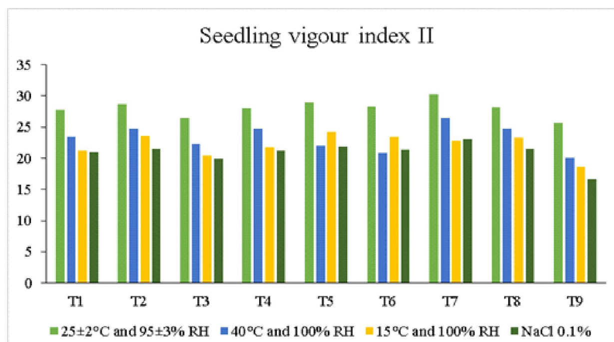
Treatments (T)	Germination conditions (C)			
	(C_1) 25±2°C and 95±3% RH	(C_2)40°C and 100% RH	(C_3) 15°C and 100% RH	(C_4)NaCl 0.1%
T_1 - α-Tocopherol 0.5%	0.348	0.327	0.3	0.288
T_2 - α-Tocopherol 0.1%	0.35	0.329	0.302	0.29
T_3 - Ascorbic acid 0.5%	0.34	0.319	0.292	0.28
T_4 - Ascorbic acid1.0%	0.346	0.325	0.298	0.286
T_5 - Glutathione 0.05%	0.344	0.323	0.296	0.284
T_6 - Glutathione 0.1%	0.341	0.32	0.293	0.281
T_7 - BHT 0.1%	0.356	0.335	0.308	0.296
T_8 - BHT 0.2%	0.347	0.326	0.299	0.287
T_9 - Control	0.325	0.3	0.269	0.245
Mean	0.344	0.323	0.295	0.282
CD (P=0.05)	T= 0.004 **	C=0.002 **	TxC= NS	



Treatments represents :

T_1 - α-Tocopherol 0.5% ; T_2 - α-Tocopherol 1.0% ; T_3 - Ascorbic acid 0.5% ; T_4 - Ascorbic acid 1% ; T_5 - Glutathione 0.05% ; T_6 - Glutathione 0.1% ; T_7 - Butylated hydroxy toluene 0.1 % ; T_8 - Butylated hydroxy toluene 0.2 % ; T_9 - Control

Fig. 1. Effect of seed priming with antioxidants on vigour index I under favourable and unfavourable germination conditions in sunflower cv. Co-2



Treatments represents :

T_1 - α-Tocopherol 0.5% ; T_2 - α-Tocopherol 1.0% ; T_3 - Ascorbic acid 0.5% ; T_4 - Ascorbic acid 1% ; T_5 - Glutathione 0.05% ; T_6 - Glutathione 0.1% T_7 - Butylated hydroxy toluene 0.1% ; T_8 - Butylated hydroxy toluene 0.2% ; T_9 - Control

Fig. 2. Effect of seed priming with antioxidants on vigour index II under favourable and unfavourable germination conditions in sunflower cv. Co-2

Butylated hydroxy toluene 0.1 per cent were subjected to (C_2) 40°C and 100 % RH. Which is 11.16 per cent higher than the (T_9) control (19.5cm)

The interaction between antioxidant treatments and germination conditions was found to be non-significant for seedling dry matter (Table 4). The interaction effect showed that seed primed with (T_7) Butylated hydroxy toluene 0.1 per cent recorded the highest vigour index I (4124) which was 25.92 per cent more over (T_9) control and vigour index II (26.5) which was 23 per cent more over control (T_9) under

(C_2) 40 °C and 100 per cent RH. Interaction effect showed that seed primed with (T_7) Butylated hydroxy toluene 0.1 per cent recorded the highest vigour index II (26.5) which was 23 per cent more over control (T_9) under (C_2) 40 °C and 100 per cent RH (Fig.1 and 2). Thus, the present study revealed that the better performance of seedlings even under stress conditions could possibly be due to antioxidant treatment providing protection against stress at a low level of concentration and certain biochemical strategies were used to enhance salt tolerance in plants, including the control of ion transfer from roots to leaves, the distribution of ions into cellular compartments, the synthesis of osmotic regulators, changes in photosynthesis and cell membranes and the induction of antioxidative enzymes and certain plant hormones (Nakamura *et al*., 2002).

Under favourable germination conditions of 25±2 °C and 95±3 per cent RH also the influence of Buty lated hydroxytoluene 0.1 per cent was much more pronounced followed by Glutathione 0.05 per cent with an increase in germination by 6 and 5 per cent respectively over control seeds. There was a corresponding decline in abnormal seedling production also due to the above treatments. However, it was evident from the study that no antioxidant priming treatment could improve the performance of germination and seedling growth attributes under unfavourable germination conditions as that of the favourable condition 25±2 °C and 95±3 per cent RH Seed priming with either Butylated hydroxytoluene 0.1 per cent or α-Tocopherol 0.5 per cent and Ascorbic acid 1.0 per cent had alleviated the effect of unfavourable germination condition stress by increasing the germination, seedling growth and vigour indices though not up to the level of performance in stress free favourable germination condition.

To find out the effect of antioxidants on the physiological performance of sunflower seeds under favourable and different unfavourable germination conditions, a laboratory experiment was conducted where the seeds of sunflower cv. Co-2 was primed with eight antioxidants and subjected to three unfavourable germination conditions and favourable germination conditions of 25±2 °C and 95±3 per cent RH were maintained as the control for comparison. The results revealed that 40 °C and 100 per cent RH exerted more stress on seed germination. The effect of stress was minimized by seed priming with Butylated hydroxy toluene 0.1 per cent followed by Butylated hydroxy toluene 2 per cent by recording 7 and 4 per cent higher germination over control. The seedling growth parameters *viz.,* root and shoot length, seedling dry matter production and vigour indices were influenced negatively by NaCl 0.1 per cent stress condition. Seed priming with Butylated hydroxy toluene 0.1 per cent followed by α-Tocopherol 0.5 per cent and Ascorbic acid 1.0 per cent was found to have a positive influence on the enhancement of seedling growth attributes under unfavourable germination conditions.

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