

TABLE S1: Role of melatonin in drought and high-temperature stress on crop yield

S.NO	Plant species	Stress treatment	Melatonin concentration	Method of application	Effects	Reference
1.	Tomato (<i>Solanum lycopersicum</i> L.)	Withholding irrigation and maintaining at different irrigation regimes	20 ppm	Foliar application	<ul style="list-style-type: none"> Increased chlorophyll content and antioxidant enzymes. Reduced ROS and MDA Increased yield (37.4%) 	[34]
2.	Flax (<i>Linum usitatissimum</i> L.)	Withholding irrigation at two levels (50% FC, and 75% FC)	5 mM	Soil application	<ul style="list-style-type: none"> Increased chlorophyll content and antioxidant enzymes. Positively increased yield 	[35]
3.	Soyabean (<i>Glycine max</i> L.)	Withholding irrigation (20% FC)	100 μ M	Seed coating	<ul style="list-style-type: none"> Increased chlorophyll content. Reduced electrolyte leakage No significant increase in yield 	[36]
4.	Cotton (<i>Gossypium hirsutum</i> L.)	Withholding irrigation for 9 days	100 μ M	Foliar application	<ul style="list-style-type: none"> Improved the yield 	[37]
5.	lemon verbena (<i>Lippia citriodora</i>)	four levels of drought at 75% FC (mild drought), 50% FC (moderate drought), and 25% FC (severe drought) for 45 days	100 μ M	Foliar application (Once a week for 45 days)	<ul style="list-style-type: none"> Increased chlorophyll content and antioxidant enzymes. Reduced ROS and MDA Increased the essential oil content by 16, 31 and 21% for mild, moderate, and severe droughts, respectively) and yield (by 43 and 76% for mild and moderate droughts, respectively) 	[38]
6.	Citrus species Persian lime (<i>Citrus latifolia</i> Tanaka) and Mexican lime [<i>Citrus aurantifolia</i> (Christ.) Swingle	Withholding irrigation at two levels (75% FC, and 40% FC) for 60 days	100 μ M	Foliar application (Three times a week for 60 days)	<ul style="list-style-type: none"> Increased essential oil content by (3.15% in Persian lime and 3.05% in Mexican lime) 	[39]

7.	Soyabean (<i>Glycine max</i> L.)	Withholding irrigation (50% FC) for 13 days	100 µM	Foliar application	<ul style="list-style-type: none"> Improved the yield (10.86%) 	[40]
8.	Soyabean (<i>Glycine max</i> L.)	PEG induced drought stress for 7 days	100 µM	Foliar application	<ul style="list-style-type: none"> Increased photosynthesis and antioxidant enzymes activity Reduced ROS and MDA Increased grain yield (23.4%-42.1%) 	[41]
9.	Rice (<i>Oryza sativa</i> L.)	38 °C/28 °C for 20 days	200 µM	Foliar application	<ul style="list-style-type: none"> Increased photosynthesis Increased grain yield by reducing chalkiness 	[42]
10.	Rapeseed (<i>Brassica</i> sp)	Withholding irrigation (35-40%.FC)	500 µM	Seed priming	<ul style="list-style-type: none"> Increased photosynthesis Increased grain yield (14%) 	[43]
11.	Soyabean (<i>Glycine max</i> L.)	Withholding irrigation (50%.FC) for 24 days	100 µM.	Foliar application for first five days from onset of drought	<ul style="list-style-type: none"> Increased photosynthesis and antioxidant enzymes activity Reduced ROS and MDA Increased grain yield 	[44]
12.	Tea (<i>Camellia sinensis</i> L.)	Withholding irrigation for 7 and 14 days	100 µM	Foliar application	<ul style="list-style-type: none"> Increased yield 	[45]
13.	Olive cultivars (<i>Olea europea</i> cv. Sevillana & Roughani	Withholding irrigation (75%, and 50%.FC) for 24 days	100 µM	Foliar application	<ul style="list-style-type: none"> Increased chlorophyll content Increased photosynthesis and antioxidant enzymes activity Reduced ROS and MDA Increased grain yield 	[46]
14.	Sweet cherry (<i>Prunus avium</i> L.)	Withholding irrigation (75%, 50%, and 25% FC)	200 µM	Foliar application	<ul style="list-style-type: none"> Increased chlorophyll content Increased grain yield 	[47]

MEAN and ANOVA for physiological and yield traits.

TABLE S2: Effect of different stress and melatonin treatment on chlorophyll index (SPAD) in tomato

Treatments	D	HT	D+HT
Absolute Control	51.78 ± 0.39	51.78 ± 0.39	51.78 ± 0.39
Stress Control	38.83 ± 0.64	35.75 ± 0.52	32.15 ± 0.27
80 µM Melatonin	42.75 ± 0.34	38.70 ± 0.42	34.30 ± 0.46
100 µM Melatonin	44.45 ± 0.39	40.33 ± 0.49	35.38 ± 0.29
	MSS	F value	Sig
Stress (Factor A)	146.651	199.487	***
Foliar spray (Factor B)	605.162	823.195	***
S x FS	17.341	23.588	***

TABLE S3: Effect of different stress and melatonin treatment on thylakoid membrane damage (F_0/F_m) in tomato

Treatments	D	HT	D+HT
Absolute Control	0.19 ± 0.05	0.19 ± 0.01	0.19 ± 0.01
Stress Control	0.33 ± 0.02	0.38 ± 0.02	0.44 ± 0.01
80 µM Melatonin	0.26 ± 0.01	0.32 ± 0.01	0.39 ± 0.01
100 µM Melatonin	0.23 ± 0.01	0.28 ± 0.01	0.36 ± 0.01
	MSS	F value	Sig
Stress (Factor A)	0.032	78.215	***
Foliar spray (Factor B)	0.079	193.889	***
S x FS	0.004	9.094	***

TABLE S4: Effect of different stress and melatonin treatment on photosynthetic rate (P_n) in tomato

Treatments	D	HT	D+HT
Absolute Control	37.12 ± 0.29	37.12 ± 0.29	37.12 ± 0.29
Stress Control	24.22 ± 0.21	20.71 ± 0.09	16.53 ± 0.37
80 µM Melatonin	27.63 ± 0.07	23.48 ± 0.22	18.56 ± 0.26
100 µM Melatonin	30.06 ± 0.13	25.16 ± 0.36	19.59 ± 0.18
	MSS	F value	Sig
Stress (Factor A)	185.696	743.969	***
Foliar spray (Factor B)	647.988	2596.090	***
S x FS	21.922	87.827	***

TABLE S5: Effect of different stress and melatonin treatment on transpiration rate (E) in tomato

Treatments	D	HT	D+HT
Absolute Control	8.71 ± 0.05	8.71 ± 0.05	8.71 ± 0.05
Stress Control	4.35 ± 0.06	5.87 ± 0.04	2.60 ± 0.06
80 µM Melatonin	4.72 ± 0.03	6.32 ± 0.06	2.79 ± 0.05
100 µM Melatonin	4.94 ± 0.08	6.65 ± 0.05	2.93 ± 0.03
	MSS	F value	Sig
Stress (Factor A)	27.715	2625.115	***
Foliar spray (Factor B)	52.026	4927.840	***
S x FS	3.113	294.885	***

TABLE S6: Effect of different stress and melatonin treatment on stomatal conductance (g_s) in tomato

Treatments	D	HT	D+HT
Absolute Control	0.35 ± 0.009	0.35 ± 0.009	0.35 ± 0.009
Stress Control	0.20 ± 0.007	0.25 ± 0.006	0.16 ± 0.006
80 µM Melatonin	0.23 ± 0.004	0.28 ± 0.009	0.18 ± 0.005
100 µM Melatonin	0.26 ± 0.007	0.30 ± 0.005	0.20 ± 0.004
	MSS	F value	Sig
Stress (Factor A)	0.021	104.989	***
Foliar spray (Factor B)	0.051	256.817	***
S x FS	0.002	12.370	***

TABLE S7: Effect of different stress and melatonin treatment on intercellular CO₂ concentration (C_i) in tomato

Treatments	D	HT	D+HT
Absolute Control	110.38 ± 2.26	110.38 ± 2.26	110.38 ± 2.26
Stress Control	186.31 ± 4.56	172.00 ± 5.04	189.65 ± 2.09
80 µM Melatonin	155.09 ± 4.08	153.80 ± 4.96	174.43 ± 3.82
100 µM Melatonin	129.69 ± 4.28	127.34 ± 3.72	147.89 ± 3.53
	MSS	F value	Sig
Stress (Factor A)	908.738	16.439	***
Foliar spray (Factor B)	11823.150	213.878	***
S x FS	160.924	2.911	*

TABLE S8: Effect of different stress and melatonin treatment on hydrogen peroxide (H₂O₂) content in tomato

Treatments	D	HT	D+HT
Absolute Control	1.93 ± 0.04	1.93 ± 0.04	1.93 ± 0.04
Stress Control	3.73 ± 0.07	4.25 ± 0.03	4.75 ± 0.04
80 µM Melatonin	3.29 ± 0.04	3.87 ± 0.04	4.41 ± 0.06
100 µM Melatonin	2.92 ± 0.04	3.57 ± 0.03	4.15 ± 0.05
	MSS	F value	Sig
Stress (Factor A)	2.836	365.891	***
Foliar spray (Factor B)	12.380	1597.123	***
S x FS	0.322	41.611	***

TABLE S9: Effect of different stress and melatonin treatment on superoxide anion content (O₂⁻) in tomato

Treatments	D	HT	D+HT
Absolute Control	0.167 ± 0.002	0.167 ± 0.002	0.167 ± 0.002
Stress Control	0.423 ± 0.010	0.495 ± 0.004	0.555 ± 0.004
80 µM Melatonin	0.373 ± 0.008	0.445 ± 0.004	0.506 ± 0.007
100 µM Melatonin	0.344 ± 0.007	0.412 ± 0.003	0.480 ± 0.010
	MSS	F value	Sig
Stress (Factor A)	0.040	299.858	***
Foliar spray (Factor B)	0.250	1897.979	***
S x FS	0.004	33.479	***

TABLE S10: Effect of different stress and melatonin treatment on malondialdehyde (MDA) content in tomato

Treatments	D	HT	D+HT
Absolute Control	0.29 ± 0.016	0.29 ± 0.016	0.29 ± 0.016
Stress Control	0.64 ± 0.013	0.68 ± 0.015	0.75 ± 0.015
80 µM Melatonin	0.50 ± 0.016	0.54 ± 0.018	0.62 ± 0.011
100 µM Melatonin	0.43 ± 0.009	0.47 ± 0.017	0.55 ± 0.016
	MSS	F value	Sig
Stress (Factor A)	0.034	41.517	***
Foliar spray (Factor B)	0.333	406.383	***
S x FS	0.004	4.390	**

TABLE S11: Effect of different stress and melatonin treatment on electrolyte leakage (EL) in tomato

Treatments	D	HT	D+HT
Absolute Control	6.53 ± 0.14	6.53 ± 0.14	6.53 ± 0.14
Stress Control	26.65 ± 0.54	32.88 ± 0.38	41.58 ± 0.45
80 µM Melatonin	23.33 ± 0.34	29.88 ± 0.36	38.90 ± 0.41
100 µM Melatonin	22.03 ± 0.19	27.93 ± 0.29	36.40 ± 0.52
	MSS	F value	Sig
Stress (Factor A)	508.160	1010.845	***
Foliar spray (Factor B)	1855.192	3690.394	***
S x FS	56.704	112.796	***

TABLE S12: Effect of different stress and melatonin treatment on superoxide dismutase activity (SOD) in tomato

Treatments	D	HT	D+HT
Absolute Control	102.38 ± 1.82	102.38 ± 1.82	102.38 ± 1.82
Stress Control	166.60 ± 2.03	139.35 ± 1.62	194.45 ± 3.81
80 µM Melatonin	184.86 ± 1.56	151.74 ± 2.49	205.61 ± 2.98
100 µM Melatonin	194.83 ± 0.76	158.32 ± 1.98	214.66 ± 2.15
	MSS	F value	Sig
Stress (Factor A)	6899.104	357.461	***
Foliar spray (Factor B)	18611.060	964.289	***
S x FS	785.541	40.701	***

TABLE S13: Effect of different stress and melatonin treatment on catalase (CAT) activity in tomato

Treatments	D	HT	D+HT
Absolute Control	0.11 ± 0.006	0.11 ± 0.006	0.11 ± 0.006
Stress Control	0.29 ± 0.010	0.21 ± 0.011	0.37 ± 0.012
80 µM Melatonin	0.34 ± 0.016	0.24 ± 0.010	0.40 ± 0.010
100 µM Melatonin	0.36 ± 0.011	0.25 ± 0.009	0.42 ± 0.019
	MSS	F value	Sig
Stress (Factor A)	0.062	136.202	***
Foliar spray (Factor B)	0.131	287.884	***
S x FS	0.007	15.590	***

TABLE S14: Effect of different stress and melatonin treatment on peroxidase (POD) activity in tomato

Treatments	D	HT	D+HT
Absolute Control	0.11 ± 0.002	0.11 ± 0.002	0.11 ± 0.002
Stress Control	0.24 ± 0.006	0.17 ± 0.002	0.31 ± 0.005
80 µM Melatonin	0.28 ± 0.003	0.19 ± 0.003	0.35 ± 0.010
100 µM Melatonin	0.31 ± 0.006	0.21 ± 0.003	0.37 ± 0.011
	MSS	F value	Sig
Stress (Factor A)	0.052	405.597	***
Foliar spray (Factor B)	0.079	614.387	***
S x FS	0.006	46.565	***

TABLE S15: Effect of different stress and melatonin treatment on ascorbate peroxidase (APX) activity in tomato

Treatments	D	HT	D+HT
Absolute Control	0.03 ± 0.004	0.03 ± 0.004	0.03 ± 0.004
Stress Control	0.22 ± 0.005	0.16 ± 0.004	0.10 ± 0.003
80 µM Melatonin	0.25 ± 0.004	0.18 ± 0.007	0.11 ± 0.005
100 µM Melatonin	0.28 ± 0.004	0.20 ± 0.005	0.13 ± 0.003
	MSS	F value	Sig
Stress (Factor A)	0.042	511.000	***
Foliar spray (Factor B)	0.070	866.077	***
S x FS	0.005	59.308	***

TABLE S16: Effect of different stress and melatonin treatment on glutathione reductase (GR) activity in tomato

Treatments	D	HT	D+HT
Absolute Control	32.49 ± 0.83	32.49 ± 0.83	32.49 ± 0.83
Stress Control	59.58 ± 0.87	47.12 ± 0.69	51.33 ± 0.63
80 µM Melatonin	67.20 ± 0.53	52.64 ± 0.74	56.69 ± 1.56
100 µM Melatonin	71.72 ± 0.44	55.61 ± 0.80	58.67 ± 0.73
	MSS	F value	Sig
Stress (Factor A)	499.866	180.104	***
Foliar spray (Factor B)	2107.646	759.395	***
S x FS	59.752	21.529	***