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Alleviation of High Temperature Stress in Sunflower (*Helianthus Annus* L.) By Plant Growth Regulators and Chemicals

R. Amutha, S. Muthulaksmi, W. Baby Rani K. Indira and P. Mareeswari

Regional Research Station, Aruppukottai, Tamil Nadu Agricultural UIniversity, Tamil Nadu, India.

Abstract: An experiment was conducted in farmer's field at Aruppukottai, Tamil Nadu during summer 2004 to study the effect of various plant growth regulators and chemicals on endurance of high temperature by Sunflower. Based on the screening studies for heat stress, the tolerant and sensitive sunflower genotypes were used in this experiment. The chemicals and plant growth regulators at optimum concentrations were sprayed at 35 and 50 DAS. The study revealed that among the chemicals tested, foliar application of brassinolide (0.1 ppm) at 35 and 50 DAS resulted in significant improvement in all the yield components viz., head diameter, seed number, seed yield, TDMP and harvest index. The susceptible genotype, ARM 242, showed better responses to all the growth regulating chemicals tried than the other genotypes. The highest cost benefit was also recorded in 0.1ppm Brassinolide treatment.

Key words: *Temperature stress, Genotypes, Ameliorants, Brassinolide, Yield*

NTRODUCTION

Ninety per cent of the world's sunflower production is confined to the tropical and semi-arid tropical regions, which are characterized by high temperature and low or erratic rainfall. High temperature of 38ºC to 40ºC causes reduction in seed yield, oil and protein content in sunflower. In general, growing degree days (GDD) for sunflower ranges from 1042 to 1300 with a base temperature of 10ºC.

Sunflower is predominantly grown as a rainfed crop. Although, this crop shows wide adaptability, the yield is destabilized by both abiotic and biotic stresses. Drought and high temperature are the two important abiotic stresses, which affect both vegetative and reproductive growths adversely. The coincidence of heat shock under water-limited condition is common in tropical and subtropical areas. Therefore, improvement for high temperature tolerance in sunflower is vital to stabilize the yield in these regions.

The role of plant growth regulators and chemicals in imparting adaptation to heat stress has been reviewed by Larkindale and Huang[7]. Brassinosteroids are a novel group of plant hormones that regulate cell division, cell expansion, reproductive and vascular development and retard leaf abscission and enhance resistance to stress through stabilizing membranes and DNA. Alleviating effects of cytokinin on heat injury have also been observed in bean (*Phaseolus vulgaris*), wheat (*Triticum aestivum* L.) and other cereal crops. Several studies have shown that Ca^{2+} is involved in the regulation of plant responses to various environmental stresses, including heat [3]. Increasing cytosolic Ca^{2+} content under heat stress may alleviate heat injury and enable plant cells to survive better.

High temperature stress commonly occurring during plant growth and development is responsible for major yield losses in crop plants [2]. Heat stress induces decrease in duration of developmental phases leading to fewer organs, smaller organs, reduced light perception, over shortened life cycle and perturbation of the processes related to carbon assimilation (transpiration, photosynthesis and respiration) which are responsible factors for reduction in crop yields. The reproductive processes are also severely affected due to high stress. The temperature threshold for damage by high temperature in reproductive organ is considerably lower than in other crop organs.

Several of these responses are associated with changes in production and translocation of hormones and finally affect the yield. Improving the productivity of crop plants under moderately high temperature has practical relevance. One of the approaches is spraying plants with an appropriate hormone at low doses that can overcome these effects. Some of the harmful effects of high temperature stress that were reported earlier could be relieved by the application of plant hormones in *Agrotis stolonifera* [7], sunflower [5], peanut [11], greengram [9] and cucurbita [2]. With these ideas in view, this experiment was planned to find out the effect of various plant growth regulators and chemicals on endurance of high temperature in sunflower.

3Corresponding Author: R. Amutha, Regional Research Station, Aruppukottai, Tamil Nadu Agricultural UIniversity, Tamil Nadu, India.

MATERIALS AND METHODS

An experiment was conducted in farmer's field at Aruppukottai, Tamil Nadu during summer 2004 to study the effect of various plant growth regulators and chemicals on endurance of high temperature by sunflower. The field experiment was conducted in summer season and irrigation was given once in a week. Based on the screening studies for heat stress, the tolerant and sensitive sunflower genotypes were used in this experiment. The chemicals and plant growth regulators at optimum concentrations were sprayed at 35 and 50 DAS.

The experiment was laid out in a split plot design and replicated thrice. In the main plot four genotypes viz., Morden and CO 4 (tolerant genotypes), EC 68415 and ARM 242 (sensitive genotypes) were tested. Growth regulators and chemicals viz., Brassinolide 0.1 ppm, Salicylic acid 100 ppm,Benzyl adenine 10 ppm, CaCl2 0.5 per cent, Potassium dihydrogen phosphate 1.0 per cent along with control numbering six treatments were fitted in the sub plot. Head diameter, total number of seeds, seed density, hundred seed weight, seed yield and total dry matter production (TDMP) and yield were recorded. Harvest Index was calculated by dividing the economic yield by total biological yield.

RESULTS AND DISCUSSIONS

Head diameter: The chemicals viz., brassinolide, salicylic acid, benzyl adenine, CaCl2 and KH2PO4 increased the head diameter significantly over unsprayed control, with well pronounced effect in ARM 242 than in

Table 1: Effect of plant growth regulating chemicals on head diameter (cm) of sunflower genotypes under high temperature stress

	Head diameter (cm)				
Treatments/ genotypes	Morden	CO 4	EC 68415	ARM 242	Mean
Control	8.02	9.31	6.32	7.64	7.73
Brassinolide	8.63(7.61)	9.74(4.62)	6.85(8.39)	8.94(17.05)	8.54
Salicylic acid	8.47(5.61)	9.73(4.51)	6.80(7.59)	8.85(15.83)	8.46
Benzyl adenine	8.26(3.00)	9.55(2.58)	6.69(5.85)	8.71(14.00)	8.30
$Cacl_2$	8.19(2.12)	9.51(2.15)	6.23(6.23)	8.67(13.48)	8.15
KH_2PO_4	8.36(4.12)	9.68(3.97)	6.75(6.80)	8.68(13.61)	8.29
Mean	8.32	9.58	8.52	6.58	

	SEd	CD (0.05)
Genotypes	0.13	0.26
Treatments	0.16	0.40
Genotypes x treatments	0.32	0.64

(Values in the parentheses indicate per cent increase over control)

Table 2: Effect of plant growth regulating chemicals on seed density (numbers cm^{-2}) of sunflower genotypes under high temperature stress

	Seed density (numbers cm^{-2})				
Treatments/ genotypes	Morden	CO 4	EC 68415	ARM 242	Mean
Control	5.84	6.64	5.42	4.05	5.48
Brassinolide	6.28(7.53)	7.00(5.42)	6.18(14.02)	4.79(18.27)	6.06
Salicylic acid	6.19(5.99)	6.98(5.12)	6.13(11.25)	4.63(14.32)	5.98
Benzyl adenine	6.02(3.08)	6.73(1.14)	5.90(8.86)	4.57(12.84)	5.80
$CaCl_2$	5.92(1.37)	6.70(0.90)	5.85(7.79)	4.48(10.62)	5.73
KH_2PO_4	6.19(6.19)	6.85(3.16)	5.94(8.59)	4.61(13.83)	5.89
Mean	6.07	6.81	5.90	4.52	

	SEd	CD (0.05)
Genotypes	0.08	0.17
Treatments	0.10	0.21
Genotypes x treatments	0.21	0.43

(Values in the parentheses indicate per cent increase over control)

Table 3: Effect of plant growth regulating chemicals on hundred seed weight (g) of sunflower genotypes under high temperature stress

	Hundred seed weight (g)				
Treatments/ genotypes	Morden	CO 4	EC 68415	ARM 242	Mean
Control	3.01	3.38	2.15	2.02	2.68
Brassinolide	3.23(4.19)	3.50(3.50)	2.51(16.74)	2.43(20.29)	2.91
Salicylic acid	3.23(4.19)	3.48(2.96)	2.55(18.60)	2.40(18.81)	2.91
Benzyl adenine	3.11(3.32)	3.41(0.89)	2.45(13.95)	2.35(16.34)	2.83
$CaCl_2$	3.05(1.33)	3.41(0.89)	2.36(9.76)	2.26(11.88)	2.77
KH_2PO_4	3.15(4.65)	3.45(2.07)	2.51(16.74)	2.38(17.82)	2.87
Mean	3.13	3.43	2.42	2.33	

	SEd	CD (0.05)
Genotypes	0.04	0.08
Treatments	0.05	0.10
Genotypes x treatments	0.10	0.21

(Values in the parentheses indicate per cent increase over control)

Table 4: Effect of plant growth regulating chemicals on seed yield (kg ha^{-1}) of sunflower genotypes under high temperature stress

	Seed yield (kg ha^{-1})				
Treatments/ genotypes	Morden	CO 4	EC 68415	ARM 242	Mean
Control	769.48	813.14	672.8	618.5	718.5
Brassinolide	838.3(8.94)	871.2(7.14)	779.4(15.86)	718.9(16.22)	802.0
Salicylic acid	827.8(7.58)	865.4(6.04)	763.9(13.55)	705.5(14.06)	790.7
Benzyl adenine	823.9(7.07)	830.3(2.11)	736.1(9.41)	690.3(11.60)	770.1
$CaCl_2$	814.4(5.84)	820.5(0.91)	719.5(6.95)	668.3(8.05)	755.7
KH_2PO_4	825.4(7.27)	849.5(4.47)	751.0(11.62)	696.6(12.62)	780.6
Mean	816.6	841.7	737.1	683.0	

	SEd	CD (0.05)
Genotypes	10.77	21.68
Treatments	13.19	26.56
Genotypes x treatments	26.39	53.11

(Values in the parentheses indicate per cent increase over control)

other genotypes. Application of brassinolide (0.1 ppm) and salicylic acid (100 ppm) resulted in higher head diameter than the other treatments. This might be due to enhanced source activity and protective role of these plant growth regulators under high temperature stress.

Seed density and hundred seed weight: Decreased 100 seed weight was obtained due to heat stress as compared to control. Application of chemicals were effective in increasing the seed weight, particularly brassinolide application enhanced the seed weight by 3.50, 4.19, 16.74 and 20.29 per cent in CO 4, Morden, EC 68415 and ARM 242 respectively. Similar effect of brassinolide in Maize has already been reported [11]. Brassinolide might have enhanced water and nutrient uptake and subsequently the partitioning percentage and translocation especially to reproductive parts which in turn, increased the 1000 grain weight in cereals as reported by Sairam[8]. Asgarjalis[1] have reported that wheat seeds treated with 0.5 per cent $CaCl_2$ registered the highest grain yield due to higher 100 grain weight and number of grains per ear.

Seed yield: Spraying of plant growth regulators showed profound influence on seed yield and the effect was significant in all the four genotypes of sunflower. The increase in yield might be due to increased sink size (mainly number of seeds) and seed weight. It may be related with increased photosynthetic efficiency by stabilization of chlorophyll, higher production and translocation of organic material from source to sink. Brassinolide was known to regulate cell division,cell expansion, reproductive and vascular development, retard leaf abscission and enhance resistance to stress. Brassinolide limits the loss of some of the components of

Table 5: Effect of plant growth regulating chemicals on TDMP (g m^{-2}) of sunflower genotypes under high temperature stress

	TDMP (g m^{-2})				
Treatments/ genotypes	Morden	CO 4	EC 68415	ARM 242	Mean
Control	207	212	171	160	187.5
Brassinolide	227(9.66)	228(7.54)	209(22.22)	203(26.87)	216.75
Salicylic acid	211(1.93)	222 (4.72)	205(19.88)	199(24.37)	211.75
Benzyl adenine	210(1.45)	215(1.42)	189(7.60)	184(15.00)	198.50
$CaCl_2$	209(0.97)	215(1.42)	188(9.94)	180(12.500	198.00
KH_2PO_4	211(1.93)	217(2.30)	190(11.11)	195(21.88)	203.25
Mean	214.16	218.17	192.0	186.17	

	SEd	CD (0.05)
Genotypes	2.80	5.64
Treatments	3.43	6.91
Genotypes x treatments	6.87	13.82

(Values in the parentheses indicate per cent increase over control)

Table 6: Effect of plant growth regulating chemicals on harvest index sunflower genotypes under high temperature stress

	Harvest index				
Treatments/ genotypes	Morden	CO 4	EC 68415	ARM 242	Mean
Control	0.302	0.353	0.281	0.273	0.273
Brassinolide	0.327(8.28)	0.371(5.10)	0.319 (13.52)	0.316 (15.75)	0.333
Salicylic acid	0.323 (6.95)	0.368 (4.25)	0.313 (11.34)	0.306 (12.08)	0.328
Benzyl adenine	0.315 (4.30)	0.362 (2.55)	0.309(9.96)	0.297(6.96)	0.321
$CaCl_2$	0.311 (2.98)	0.350 (0.85)	0.307(9.45)	0.292 (16.96)	0.315
KH_2PO_4	0.319 (5.63)	0.362 (2.55)	0.311 (1.07)	0.303 (10.99)	0.324
Mean	0.316	0.341	0.307	0.298	

	SEd	CD (0.05)
Genotypes	0.004	0.008
Treatments	0.004	0.010
Genotypes x treatments	0.010	0.02

(Values in the parentheses indicate per cent increase over control)

the translational apparatus during prolonged heat stress and increases the level of expression of some of the components of the translational machinery during recovery, which correlates with a more rapid resumption of cellular protein synthesis that result in a higher yield.

Total Dry Matter Production: The first prerequisite for higher yields is increase in the total dry matter production (TDMP). Generally, plant biomass decreases under high temperature conditions. In the present study, the genotype CO 4 had higher TDMP than ARM 242. This was supported in sunflower under water stress condition [5,6]. The probable reason might be the increased source activity and better translocation of assimilates to the sink as the results of beneficial effect of some ameliorants applied exogenously. In the present study, brassinolide sprayed plants had higher TDMP followed by salicylic acid, KH_2PO_4, BA and $CaCl_2$. Potassium dihydrogen phosphate improved the biomass accumulation by enhancing the leaf water potential and this might have led to higher CO_2 exchange rate and hence the positive effect. Potassium as a nutrient is of utmost importance in maintaining the water status of plant. It plays a major role in osmotic adjustment and thereby restricts the water loss from cells. As phosphorus is an essential element for membrane stability, KH_2PO_4 also maintains the plasma membrane integrity under stress condition and improves TDMP.

Harvest Index: The main factor responsible for lower seed yield in oilseed crops is their poor harvest index and net photosynthetic limitation. In the present study, the genotype CO 4 recorded higher harvest index than other genotypes. Application of growth regulators and chemicals significantly increased the harvest index in all the genotypes. This might be due to greater translocation of photosynthates with increased sink activity. Similar increase in harvest index in rice was reported by De and Haque [4] and increase in harvest index due to increased mobilization of metabolites to reproductive sinks in Maize was reported by Venkatesan [10].

Conclusion: The study revealed that among the growth regulators and chemicals tested, foliar application of brassinolide (0.1 ppm) given at 35 and 50 DAS resulted in significant improvements in all the yield components viz., head diameter, seed number, seed yield, TDMP and harvest index. The susceptible genotype, ARM 242, showed better responses to all the growth regulating chemicals tried than the other genotypes. The highest cost benefit was also noted in 0.1ppm Brassinolide treatment.

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