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Comparison of High Temperature Tolerance in Maize, Rice and Sorghum Seeds by Plant Growth Regulators

Zekeriya Akman
Department of Field Crops, Faculty of Agriculture, Süleyman Demirel University, 32600 Isparta, Turkey

Abstract: The levels of high temperatures (35, 38 and 41°C in 7 day/night) used in this study and decreased or delayed the germination of maize, rice and sorghum seeds. Growth regulator pre-treatments (especially GA_3) decreased this inhibitive effect of the high temperature to a great extends at 35 and 38°C in maize and rice seeds. In generally, no significant differences were detected between the control and kinetin treatments in maize and rice at 41°C. GA_3 increased rapidity germination and stimulated seed germination at all using temperate treatments in species. The case of sorghum for rapidity and final seed germination, plant growth regulators were effective thermal treatments at 38°C and over temperature. The high temperature was shortened the elongation of radicle and coleoptile and prevented at 35, 38 and 41°C. GA_3 enormously maintained its stimulative effect observed on the coleoptile and radicle emergence and elongation except at 41°C in rice. KIN had the lower the elongation of radicle when averaged across the GA_3 and control at high temperature conditions in all species.

Key words: High temperature stress, hormones, germination, rice, maize and sorghum

INTRODUCTION

Dry heat-treatment of seeds is used to control external and internal seed-borne pathogens such a fungi, bacteria, viruses and nematodes (Nakagawa and Yamaguchi, 1989) and to break seed dormancy. In general, the high temperature can reduce seed viability and seedling vigour (Lee *et al*., 2002; Basra *et al.*, 2004). Farooq *et al*. (2004) found that dry heat treatment (40°C for 72 h and 60°C for 24 h) resulted in lower seed germination and seedling vigour compared to control treatment in rice. This suppression of germination at supra-optimal temperatures is called thermo-inhibition (Negm *et al.,* 1972). Finch-Savage *et al*. (2004) informed that the practise of on-farm seed priming advanced emergence from moist sand cores at 30/20°C (day/night), reduced emergence at 35/28°C, delayed and reduced emergence at 40/28°C in maize cultivars. The C4 cereals, like sorghum, originated from the tropics and generally more heat and drought tolerant than C3 plants (Blum *et al*., 1990). However, Brar and Stewart (1994) reported that temperature strongly influenced the establishment of dryland sorghum (*Sorghum bicolor* (L) Moench) and as temperature increased from 15.5-37.5°C, the average time to germination decreased. Thermo-inhibition also may occurs in other species including lettuce (*Lactuca sativa* L.) (Lewak and Khan, 1977), chickpea (*Cicer arietinum* L.) (Gallardo *et al.,* 1991) and spinach (*Spinacia oleracea* L.) (Leskovar *et al.,* 1999).

The aim of this study was to determinate the effects of Plant Growth Regulators (PGR) pre-treatments under high temperatures on seed germination and seedling growth abilities in maize, rice and sorghum.

MATERIALS AND METHODS

Seed material and PGR pre-treatments: In this study, the seeds of maize (*Zea mays* L. convar. *indentata* cv. Combat) and sorghum (*Sorghum bicolor* L. cv. Rox), rice (*Oryza sativa* L. cv. Osmancik) were used as material. The seeds were surface sterilized with 1.0% sodium hypochlorite. Before sowing, they were soaked in distilled water (control, C) and of aqueous solutions of growth regulators in predetermined concentrations, 0.5 mM Kinetin (KIN), 2.0 mM Gibberellic Acid (GA_3) for 3 h at room temperature. Thereafter, the solutions were decanted off and the seeds were vacuum dried for 1 h (Braun and Khan, 1976).

Seed germination: Twenty five seeds from each treatment were placed in Petri dishes furnished with 2 sheets of Whatman No.1 filter paper moistened with 12 mL of distilled water (Kabar, 1990). A 12 cm Petri dishes for maize and rice and 9 cm dishes for sorghum seeds were used. After sowing, Petri dishes were kept in an incubator at 35, 38 and 41°C in continuous for 7 day/night. The temperatures were chosen by considering the heat treatments levels of *Gramineae* seeds (Nakagawa and Yamaguchi, 1989; Lee *et al*., 2002). Fungus attacks were

Table 1: The emergence of coleoptiles of seeds of maize, rice and sorghum treated with the Gibberellic Acid (GA_3) and Kinetin (KIN) at varied high temperature

		Rice[(a)]		Maize[(a)]		Sorghum[(a)]	
		Radicle	Coleoptile	Radicle	Coleoptile	Radicle	Coleoptile
Heat	Treatment	(Length, mm)					
	Control	18.2^{b}	9.8^{c}	13.8^{a}	8.7^{bc}	19.5^{c}	19.6^{b}
35	KIN	11.2^{bc}	11.8^{b}	8.9^{bc}	9.2^{bc}	10.1^{d}	21.0^{b}
	GA_3	36.8^{a}	20.2^{a}	18.0^{a}	17.6^{a}	29.2^{a}	29.9^{a}
	Control	7.0^{cd}	8.5^{d}	4.9^{cd}	6.5^{cd}	10.1^{d}	18.4^{b}
38	KIN	7.0^{cd}	6.5^{b}	4.0^{d}	6.9^{cd}	7.8^{b}	13.1^{c}
	GA_3	7.9^{cd}	10.4^{c}	9.5^{b}	11.7^{b}	22.6^{b}	29.5^{a}
	Control	2.3^{b}	0.0^{f}	0.0^{e}	0.0^{e}	7.1^{e}	8.1^{de}
41	KIN	4.4^{de}	0.0^{f}	0.0^{e}	0.0^{e}	6.9^{e}	6.5^{e}
	GA_3	7.2^{cd}	0.0^{f}	4.3^{d}	4.4^{d}	7.7^{e}	9.8^{d}

[(a)]The groups with the same letter are not significantly different ($p<0.05$)

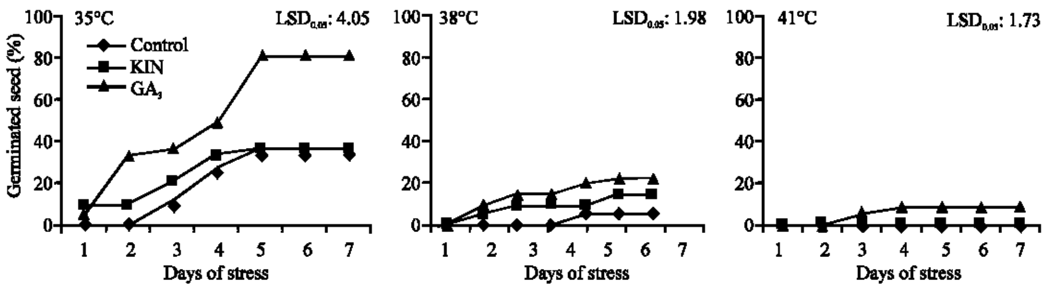

Fig. 1: Effects of temperature and hormone pre-treatments on maize seeds germination

avoided by using a fungicide (*Benlate*) at very low concentrations of 0.5 g L^{-1}, which have been proven to have no effect on seed germination. The seeds were considered to have germinated when the radicle reached 5 mm in length (Kabar, 1990). At the end of the experiment, on the 7th day, after determination of the final germination percentages, coleoptile emergence percentages were also recorded and the coleoptile and radicle lengths of the seedlings were measured by a millimetric magnifier. There were 4 replicates of 25 seeds for each treatment. Germination, coleoptile emergence and radicle and coleoptile length data were Analysis of Variance using the super ANOVA computer program. The Fig. 1 and Table 1 were produced using Excel program.

RESULTS AND DISCUSSION

Figure 1-3 show that the levels of high temperatures used in this study decreased and delayed the germination of maize, rice and sorghum seeds, respectively. High temperature strongly decreased the seed germination percentage and rapidity of maize cv. Combat as increased as the degrees of temperature from 35-41°C (Fig. 1). The seed germination was totally inhibited at 41°C in control and kinetin treatments except GA_3. Furthermore, the used maize variety in this study was more sensitive to high temperature than sorghum and rice plants (Fig. 1-3). Figure 2 shows that rice was negatively affected with the increasing temperatures from 38-41°C. However, sorghum was more tolerant to using temperature levels according to the other species (Fig. 3). Even though, increasing exposure high temperature from 38-41°C produced a significant decrease in the number of seeds germinated and sorghum final seed germination percentage was, also, retarded by high temperatures at 38 and 41°C but not at lower (35°C) temperatures. Similarly, Blum *et al.* (1990) informed that the part of sorghum seeds more resistance to heat treatments. However, Brar and Stewart (1994) reported that temperature strongly influenced the establishment of dryland sorghum (*Sorghum bicolour* (L.) Moench) and as temperature increased from 15.5-37.5°C, the average time to germination decreased significantly. In addition, lettuce (*Lactuca sativa* L.) (Lewak and Khan, 1977), chickpea (*Cicer arietinum* L.) (Gallardo *et al.*, 1991) and spinach (*Spinacia oleracea* L.) (Leskowar *et al.*, 1999) were observed that high temperatures lowered germination with respect to the control.

Growth regulator pre-treatments (especially GA_3) decreased this inhibitive effect of the high temperature to a great extends at 35 and 38°C in maize and rice seeds. GA_3 treatment dramatically stimulated in maize seed germination at temperature at 35°C, but slightly affected at 38 and 41°C (Fig. 1 and 2). The percentages seed of maximum germination were reached at 35°C in GA_3 pre-treatment at 5, 3 and 4 day the case of maize, rice and sorghum, respectively. In addition, the minimum germination value for rice was obtained at highest temperature at 41°C in kinetin and control treatments.

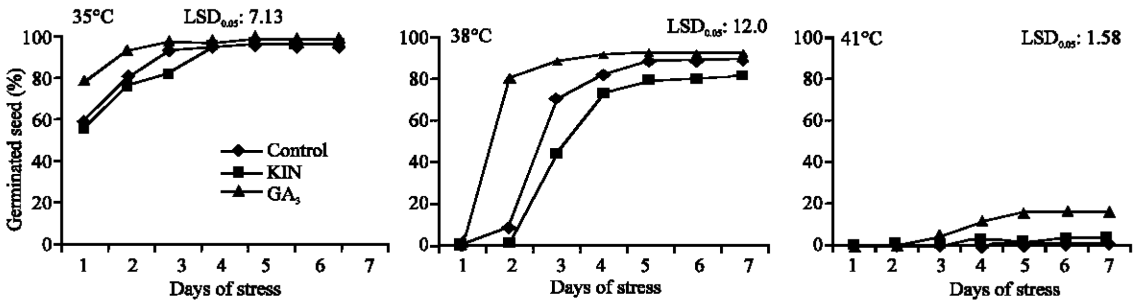

Fig. 2: Effects of temperature and hormone pre-treatments on rice seeds germination

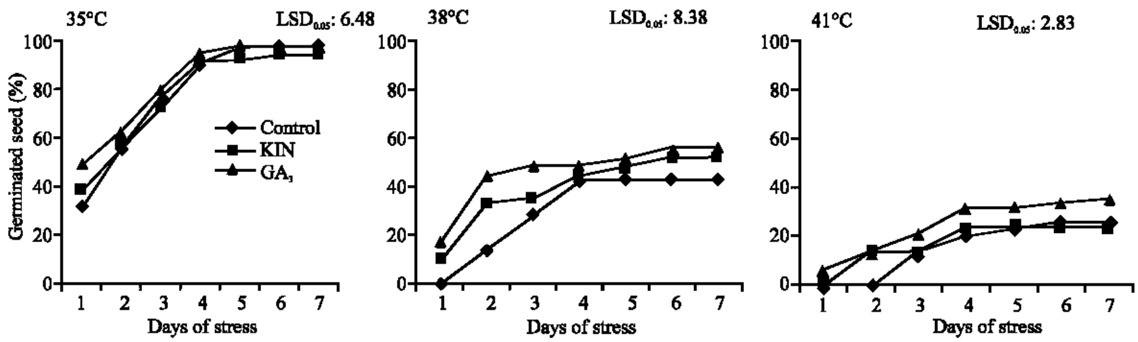

Fig. 3: Effects of temperature and hormone pre-treatments on sorghum seeds germination

Only this plant, the control surpasses kinetin treatment for germination percentage at 35 and 38°C.

As temperature increased from 35-41°C average time to germination delayed significantly ($p<0.05$) in control treatments. GA_3 increased rapidity germination and stimulated seed germination at all using temperate treatments in all species. In generally, no significant differences were detected between the control and kinetin treatments in rice, maize and sorghum at 41°C for final seed germination. Significant differences are only detected between the control and KIN at 35 and 38°C in all species and KIN affected positively the seed germination percentage. KIN slightly increased rapidity of seed germination comparison with the control at all temperatures in sorghum. Kabar (1990) reported that generally GA_3 application for monocot seeds, at least in the *Gramineae* and kinetin treatment for dicots may be more useful to a great extent. Many researchers (Saini *et al*., 1989; Huang and Khan, 1992) reported that the usefulness of treatments of plant growth regulators could stimulate germination and overcome the thermo-inhibition in many species.

Table 1 shows that the increasing temperature from 35-41°C inhibited the elongation of radicle and coleoptile of the seedlings in control treatments. The decrease in the elongation of radicle and coleoptile of the seedlings can be explained with decrease of amounts of promoter hormones and increase of the levels inhibitor substances in high temperature stressed tissues (Kabar and Baltepe, 1987). Moreover, our finding that coleoptile was more heat-sensitive than radicle is in agreement with the results given by Kabar (1990). GA_3 enormously maintained its stimulative effect observed on the coleoptile and radicle emergence as well. However, KIN had the lower the elongation of radicle when averaged across the GA_3 and control treatments. Similarly, Braun and Khan (1976) reported that KIN and its combinations reduced radicle elongation of barley and lettuce seedlings.

CONCLUSION

The growth regulators, especially GA_3, not only increased percentage germination of the seeds under high temperature but also shortened the time required for germination. Except for rice at 41°C, exogenously applied GA_3 stimulated the coleoptile and radicle emergence at experimental temperatures in all species.

REFERENCES

Basra, S.M.A., M. Ahraf, N. Igbal, A. Khalig and R. Ahmad, 2004. Physiological and biochemical aspects of pre-sowing heat stress on cottonseed. Seed Sci. Technol., 33 (3): 837-846. http://shahzadbasra.googlepages.com/cottonseeddeterio.SST-18.pdf.

Blum, A., S. Ramaiah, E.T. Kanenasu and G.M. Paulsen, 1990. The physiology of heterosis in sorghum with respect to environmental stress. Ann. Bot., 65: 149-158.

Brar, G.S. and B.A. Stewart, 1994. Germination under controlled temperature and field emergence of 13 sorghum cultivars. Crop Sci., 34 (5): 1336-1340. http://crop.scijournals.org/cgi/content/abstract/34/5/1336.

Braun, J.W. and A.A. Khan, 1976. Alleviation of salinity and high temperature stress by plant growth regulators permeated into lettuce seeds via acetone. J. Am. Soc. Hort. Sci., 101: 716-721.

Farooq, M., M.A. Basra, K.A. Hafeez and E.A. Warriach, 2004. Influence of high and low-temperature treatments on eed germination and seedling vigor of coarse and fine rice. Int. Rice Res. Newsl., 29 (2): 75-77. http://64.233.183.104/search?q=cache:WHXZgRxezlIJ:www.irri.org/publications/irrn/pdfs/vol29no2/Crop%2520Manage...pdf+Rice+Res.+Newsl.+Farooq,+M.,+M.A.+Basra&hl=tr&ct=clnk&cd=1&gl=tr.

Finch-Savage, W.E., K.C. Dent and L.J. Clark, 2004. Soak conditions and temperature following sowing influence the response of maize (*Zea mays L.*) seeds to on-farm priming (pre-sowing seed soak). Field Crops Res., 90 (2-3): 361-374. DOI: 10.1016/j.fcr.2004.04.006. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T6M-4CPD8K5-1&_user=746176&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_version=1&_urlVersion=0&_userid=746176&md5=f9bf1f5d0d7f59ce650f9cda18ad09f8.

Gallardo, M., M. Delgado, M. Del, I.M. Sanchez-Calle and A.J. Matilla, 1991. Ethylene production and 1-aminocyclopropane -1-carboxylic acid conjugation in thermoinhibited *Cicer arietinum* L., seeds. Plant Physiol., 97: 122-127. http://www.plantphysiol.org/cgi/content/abstract/97/1/122.

Huang, X.L. and A.A. Khan, 1992. Alleviation of thermoinhibition in preconditioned lettuce seeds involves ethylene, not polyamine biosynthesis. J. Am. Soc. Hort. Sci., 117: 841-845. http://cat.inist.fr/?aModele=afficheN&cpsidt=11374085.

Kabar, K. and S. Baltepe, 1987. Alleviation of salinity stress on germination of barley seeds by plant growth regulators. Doga TU. J. Biol., 3: 108-117.

Kabar, K., 1990. Comparison of kinetin and gibberellic acid effects on seed germination under saline conditions. Phyton. (Horn, Austria), 30 (2): 291-298.

Lee, S.Y., J.H. Lee and T.O. Kwan, 2002. Varietal differences in seed germination and seedling vigor of Korean rice varieties following dry heat treatments. Seed Sci. Technol., 30: 311-321.

Leskovar, D.I., V. Esensee and H. Belefaut-Miller, 1999. Pericarp, leachate and carbohydrate involvement on thermo-inhibition of germinating spinach seeds. J. Am. Soc. Hort. Sci., 124: 301-306.

Lewak, S. and A.A. Khan, 1977. Mode of action of gibberellic acid and light on lettuce seed germination. Plant Physiol., 60: 575-577. PMID: 16656940. PMCID: PMC1087042. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=542666.

Nakagawa, A. and T. Yamaguchi, 1989. Seed treatments for control of seed-borne Fusarium roseum on wheat. JARQ., 23 (2): 94-99. http://www.jircas.affrc.go.jp/english/publication/jarq/23-2/23-2-094-099.pdf.

Negm, F.B., D.E. Smitsi and J. Kumamoto, 1972. Interaction of carbon dioxide and ethylene in overcoming thermodormancy of lettuce seeds. Plant Physiol., 49: 869-872. http://www.plantphysiol.org/cgi/reprint/49/6/869.

Saini, H.S., E.D. Consolacion, P.K. Bassi and M.S. Spencer, 1989. Control processes in the induction and relief of thermoinhibition of lettuce seed germination. Actions of phytochrome and endogenous ethylene. Plant Physiol., 90: 311-315. http://www.plantphysiol.org/cgi/reprint/90/1/311.