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Wheat (*Triticum aestivum L.)* genotypes stability in different environment and their assessment under late sowing conditions

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ABSTRACT

Heat stress due to the global warming is one of the major constraints in the way of higher wheat productivity. This field study was conducted to evaluate the effect of late sowing on the wheat yield, chlorophyll content and proline accumulation in leaves. The result indicated that the Eight wheat varieties (K-7903, HUW-234,UP-2425,RAJ-3765,K-9644,PBW-373,K-9423,K-65) were treated with the heat stress condition. Heat stress were given to wheat varieties by delay sowing of 20 and 40 days from the normal date of sowing(25 november) so that the reproductive stage of first set(T_1) and vegetative as well as reproductive stage of second set (T_2) could experience heat stress. Analysis of the data showed that under heat stress condition Raj-3765 and K-7903 was minimum reduction in plant height, wheat yield, spike length and no. of grain per spike than the other wheat cultivars. While the chlorophyll content of normal sowing is greater than the late sowing treatment. The maximum chlorophyll content in treatment 1 and treatment 2 under heat stress condition was recorded in Raj-3765 while lowest chlorophyll content was recorded in K-9644. Proline was significantly high in susceptible varieties K-9644,K-9423 and UP-2425 whereas, tolerant variety Raj-3765 and K-7903 show the low proline content. From this study it could be concluded that the Morphological, physiological and Biochemical changes in wheat cultivars through the late sowing condition and from this experiment also conclude that the Raj-3765 is heat tolerance variety.

Key word: chlorophyll content, delayed sowing, proline content, wheat varieties and wheat yield

INTRODUCTION

Agricultural production worldwide is faced with severe problems caused by climate change. This golden grain winter cereal is major contributor to food security system and provides more than 50 percent calories to the people who are mostly dependent on this staple food. It is the second largest crop of India consumed after rice. Wheat sowing continues till Mid November mainly due to delayed harvesting of *kharif* crops like sugarcane and rice, and consequent late planting of wheat which reduce wheat productivity. The optimum temperature for the growth and development of spring-wheat is around 20°C (Paulsen, 1994, IPCC, 2014) , but the temperature often rises above 30°C before the physiological maturity of wheat in many wheat growing countries including India. Optimum sowing date plays an important role in yield production. Planting wheat in its optimum sowing date would realize optimum season length and achieve high grain yield as a result of suitable weather conditions prevailing through different wheat growth stages (Ouda *et al.*, 2005). Delay of wheat sowing date reduced wheat yield as a result of exposure to high temperature, which reduce season length (Abd El-Monem, 2007; Mostafa *et al.*, 2009). Yield reduction in wheat under heat stress could be caused by accelerated phases development, accelerated senescence, increased respiration, reduced photosynthesis and inhibition of starch synthesis in developing kernels (Hamam and Khaled, 2009). Temperature fluctuations during grain filling were found to cause deviations from expected dough properties (Hamam and Khaled, 2009).The rise in daily average temperature up to 30°C or more during anthesis causes pollen sterility (Rayan *et al.*, 1999). The crop may be exposed to more thermal stress in the near future, as it is predicted that the global warming may cause a temperature increase of about 2°C by the middle of twenty-first century (Karttenberg *et al.*, 1995). The relationship of high temperature to wheat yield was intensively studied by several authors and in general, the yield was reported negatively correlated to higher temperature (Wheeler *et al.*, 1996 and Batts *et al.*, 1997). The yield reduction of wheat under high temperatures is associated with a less number of grains/spike and smaller grain size (Gibson and Paulsen, 1999) and there are variations among cultivars in response to high temperature (Wardlaw and Moncur, 1995).

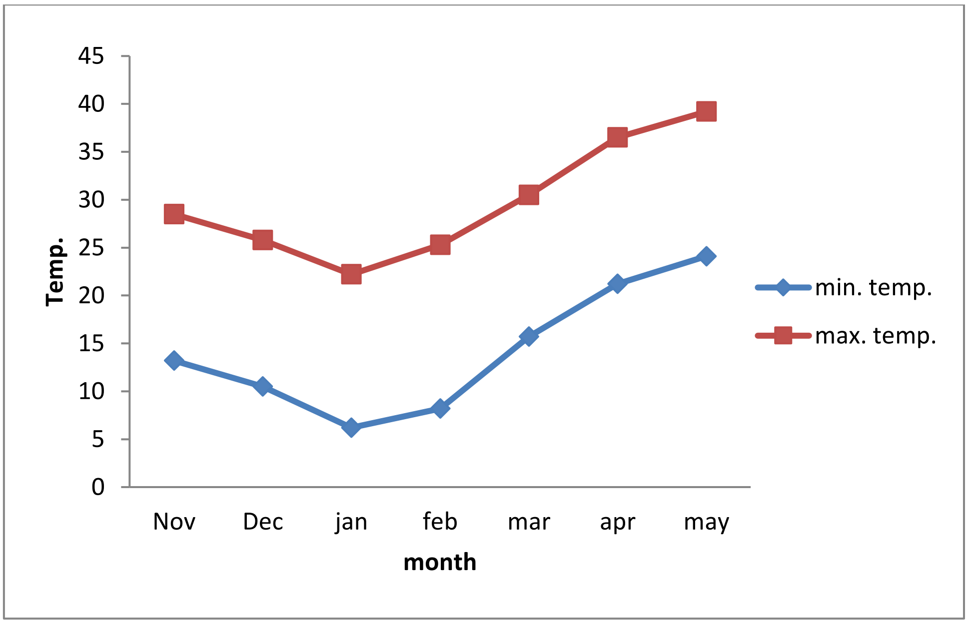
Furthermore, water stresses caused by high temperature as a result of climate change by delaying sowing date of wheat during different plant growth stages usually decreased final grain yield of wheat (Ouda *et al.*, 2005; Mostafa *et al.*, 2009; Kumar, A *et al.*,2013; Kumar, A *et al.*,2015). Also, a low soil moisture condition reduces the number of reproductive tillers which limit their contribution to grain yield (McMaster, 1997). The objective of this study were to determined the effect of late sowing on the chlorophyll content, proline content and yield of different cultivars.

METHOD AND MATERIAL

The experiment was conducted in 2021-22 at the Swami Vivekanand Subharti University, Meerut. The experiment was design in field with 8 wheat varieties K-7903, HUW-234, UP-2425, RAJ-3765, K-9644, K-9533, K-9423 and PBW-373. These seed were obtained from SVPUA&T Meerut. In field condition two heat stress treatments were given by delayed sowing of 20 and 40 days from normal sowing. The sowing was done in three sets i.e. on 25 November, 15 December and 5 January delaying by20 and 40 days from the normal sowing, respectively so that reproductive phase of second set and vegetative as well as reproductive phase of third set could come under heat stress condition. The sowing was done manually at proper depth and spacing. The recommended dose of fertilizer was given. Half dose of nitrogen and full dose of phosphate and potassium was applied as a basal dressing at the time of sowing. Rest amount of nitrogen was applied by broadcasting during crop period as per need. Irrigation was done from time to time as per need and recommendation. Uniform plant spacing was maintained by thinning after complete germination. The wheat crop was harvested at physiological maturity when symptoms of maturity were visualized as leaf turned yellow in colour and grain attained hard dough stage.

At harvest, wheat plants in one square meter from each plot were cut and counted to determine number of spikes/m2. Also, data on wheat plants i.e., plant height, number of spikelets and grain per spike, length and weight of spike, grains weight of spike and 1000-grains weight were determined from randomly selected 20 tillers.

Weakly maximum and minimum temperatures data were recorded during the rabi season of year 2021-22.



Plant Height:

The plant height was recorded from the base of stem touching the surface of ground and up to the stem apex of the plants (five selected plants) at reproductive stage of crop and average plant height was worked out.

Number of tillers per plant:

Number of tillers per plant was counted of five selected plants at reproductive stage of plant and an average tiller per plant was worked out.

Spike length:

At reproductive stage, the spikes length of five selected plants was recorded and average spike length was worked out

Number of grain per spike:

The five selected plant spikes were used for taking observation of grain per spike. Numbers of grain were counted on per plant basis.

Grain yield per plant:

Grain yield of five randomly selected plants were recorded after threshing separately average out to get grain yield plant.

Proline content

The proline content in the leaf tissue of wheat was estimated as per the method as suggested by Bates *et al.* (1973). The leaf sample of 0.5 g was homogenized in 10 ml of three per cent sulphosalicylic acid. The filtered homogenate was used for the estimation of proline. A 2 ml of the filtrate was taken in a test tube to which 2 ml of ninhydrin reagent (2.5 g of ninhydrin was dissolved in 40 ml of 6 M orthophosphoric acid and 60 ml of glacial acetic acid), 2 ml of glacial acetic acid were added. The test tubes containing the mixture were placed in boiling water bath for one hour. Then test tubes were transferred to ice bath for cooling and 4 ml of toluene was added. Then the test tube was transferred to separating funnel and shaken thoroughly and allowed for few minutes for the two layers to separate. The lower layer was discarded and upper layer toluene layer was taken into a test tube. The colour was read in spectrophotometer at 520 nm. A blank was maintained with all the reactants except the leaf extract.

Chlorophyll content:

The Chlorophyll pigment viz., Chlorophyll "a", Chlorophyll "b" and total Chlorophyll content in leaf was estimated by the method as described Hisox and Israelstam (1971). In this method fully opened top leaves were brought in polyethylene bags and were cut into small pieces. Known weight of leaves (100 mg)) was homogenized with 7 ml Dimethyl sulfoxide (DMSO) in test tube. The test tubes were kept for incubation at 65^{0}C for 50 minutes. At the end of the incubation period, supernatant liquid was decanted and the volume was made upto 10 ml with DMSO. The absorbance of the extract was read at 645 and 663 nm in spectrophotometer using Dimethyl sulfoxide as blank.

The Chlorophyll content was calculated by using the formula and expressed in mg/g fresh weight.

$$\text{Chlorophyll “a”} = 12.7\ (A663) - 269\ (A645) \times \frac{V}{1000 \times W \times A}$$

$$\text{Chlorophyll "b"} = 22.9\ (A645) - 4.68\ (A663) \times \frac{V}{1000 \times W \times A}$$

$$\text{Total Chlorophyll} = 20.2\ (A645) + 8.02\ (A663) \times \frac{V}{1000 \times W \times A}$$

Where,

A645 = Absorbance of the extract at 645 nm

A663 = Absorbance of the extract at 663 nm

a = Path length of the cuvette (1 cm)

v = Volume of the extract

w = Fresh weight of the sample (g)

RESULT AND DISCUSSION

Grain yield/ plant (g)

Heat stress had significant effect on grain yield/plant. In controlled condition, the maximum grain yield per plant was recorded in K-7903(11.5) and Raj- 3765(11.6) followed by K-9644, UP-2425, whereas minimum in K-65(9.6) and K-9423(9.8). The heat stress markedly reduced grain yield in all the varieties. Maximum reduction in grain was noted in K-65(8.8) followed by K-9423(8.2) and minimum reduction was noted in K-7903(9.8) and RAJ-3765(10.8) under T1 heat stress condition. The extent of reduction was very high under T2 heat stress condition. The highest reduction was further recorded in K-65¼7.4½ followed by K-9423¼7.8½ whearas, lowest reduction was recorded in K-7903 (8.7) and RAJ-3765(9.0). Therefor , K-7903 and Raj -3765 showed superiority over other genotypes under both T1 and T2 heat stress condition. The grain yield reduced with delay in sowing as the duration of growth and development become short. November sowing gave higher yields than December sowing. Similar results were also reported by Rajender *et al.* (1998).

Spike length (cm)

Spike length of wheat plays an important role towards the number of grains/spike and ultimately the final yield. The longest spike length was recorded in Raj-3765 followed by K-7903 and UP-2425. But under heat stress the spike length of all the varieties were decreased markedly. The maximum reduction in T1 heat stress was noted in K-65(8.5) and minimum reduction in Raj-3765(9.5). While, in T2 heat stress the highest reduction in spike length was found in K-9644(7.1) followed by K-65(7.2). There for, varieties Raj-3765(7.8) and K-7903(7.7) show less reduction in spike length. These results are in accordance with those reported by Waraich *et al.* (1981).

Number of grain/spike

Number of grains/spike is very important parameter contributing toward grain yield. Number of grains per spike depends on the length of spike and it is determined by genetic make up and environmental factors prevailing during the growth period. Number of grains per spike has a direct bearing on the final grain yield in wheat and varies with growing conditions. Under controlled condition, the maximum number of grain per spike was noted in K-7903(52.0) followed by Raj- 3765(47). When plant faced to heat stress the number of grain per spike drastically reduced. The maximum reduction under both T1 and T2 heat stresses was noted in K-65 and HUW-234. Among all the varieties the minimum percent reduction under both heat stress conditions was recorded in Raj-3765 and K-7903. The results are inconsistent with those of Ali *et al.* (1982).

Tiller number/Plant

The economic yield of most of the cereal is determined by the number of productive tillers. Fertile tillers depend on a genotype and the conditions to which crop exposed during its growth. The number of tiller per plant varied from variety to variety. The highest tiller number was recorded in K-7903 and Raj-3765 followed by K-9644. Under moderate temperature stress T1, the maximum reduction was recorded in K-65 and K-9423 followed by UP-2425. While, in high heat stress T2 it was noted in variety K-65 and UP-2425. The minimum reduction was recorded in Raj-3765 followed by K-7903. These results are in consistent with those of Spink *et al.* (2000).

Plant height at maturity (cm)

Plant height is mainly controlled by the genetic makeup of a genotype, but it is also affected by environmental conditions. All the wheat varieties showed different growth pattern under control as well as heat stress condition. The maximum plant height under controlled condition was recorded in K-9423 and PBW -373 and lowest is UP-2425 followed by K-65 at reproductive stage. The heat stress drastically reduced the plant height in all varieties. Plant height was severely reduced when degree of temperature risen from T1 and T2 heat stresses. In moderate heat stress T1, there were fewer variations in percent reduction of plant height in all wheat varieties but under high heat stress T2 the extent of variation had increased. The maximum reduction in plant height under T1 heat stress was noted in UP-2425 followed by K-65 where as in T2 heat stress it was recorded in K-9423 followed by K-65. The variety K-7903 showed lowest percent reduction under both T1 and T2 heat stresses. Melladoze (1980) had reported the similar results.

Table-1 Yield and yield characters of different wheat cultivars under normal and heat stress conditions

	Control					Treatment (T1)					Treatment (T2)				
Variety	**Plant height (cm)**	**Spike length (cm)**	**No of Grain per spike**	**No of Tiller per plant**	**Yield per Plant (g)**	**Plant height (cm)**	**Spike length (cm)**	**No of Grain per spike**	**No of Tiller per plant**	**Yield per Plant (g)**	**Plant height (cm)**	**Spike length (cm)**	**No of Grain per spike**	**No of Tiller per plant**	**Yield per Plant (g)**
K-7903	92.4	9.4	48.0	6.8	11.5	88.5	9.0	42.2	5.8	9.8	78.5	7.7	39.0	5.3	8.7
HUW 234	95.4	8.8	46.0	6.2	10.3	85.2	8.1	38.1	5.6	9.4	74.3	7.2	32.0	4.5	8.5
UP 2425	90.6	9.4	46.5	5.6	11.0	84.3	8.6	40.3	4.8	9.2	78.3	7.5	36.5	4.2	7.8
Raj 3765	92.6	10.2	47.0	7.8	11.6	85.2	9.5	40.7	7.0	10.2	72.2	7.8	38.0	6.3	9.0
K 9644	95.4	9.2	43.4	6.8	11.2	86.4	8.3	38.4	6.0	9.7	78.2	7.1	32.0	5.2	8.0
PBW 373	96.6	8.2	44.5	6.4	10.5	88.2	7.2	40.2	5.7	9.2	75.0	6.8	36.4	4.5	8.4
K-9423	98.3	8.9	43.5	5.3	9.8	86.0	8.0	38.2	4.8	8.2	78.1	6.9	31.8	4.0	7.8
K-65	91.5	9.2	42.8	5.8	9.6	85.0	8.5	36.5	4.2	8.8	74.8	7.2	30.8	3.6	7.4

MEAN	94.10	9.16	45.21	6.33	10.68	86.10	8.4	39.32	5.48	9.35	76.17	7.27	34.56	4.7	8.2
LSD(0.05)	0.80	0.27	0.63	0.26	0.25	0.50	0.23	0.61	0.17	0.19	1.79	0.12	3.27	0.28	0.08
CV%	2.68	8.52	3.96	11.9	6.6	1.6	7.8	4.3	12.9	5.9	2.9	4.7	8.7	17.0	6.0

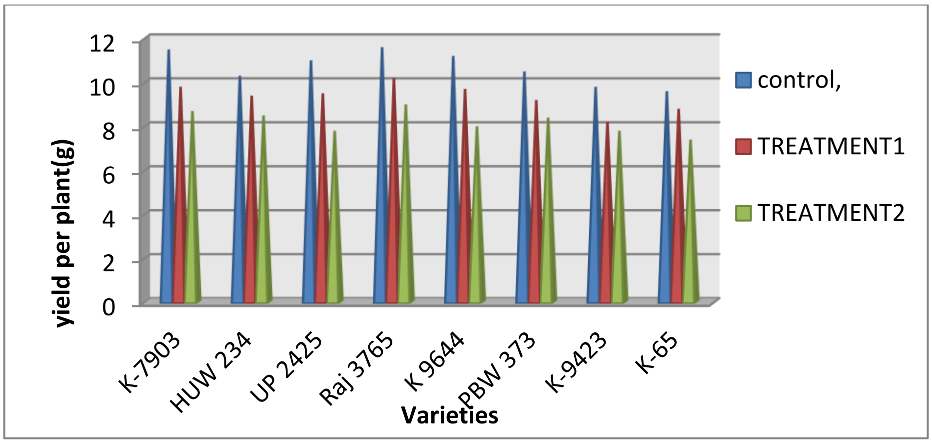


Fig: Relative biological yield in late sowing conditions compared to normal growing condition in different Wheat genotypes

Chlorophyll contents

Chlorophyll is one of the major chloroplast components for photosynthesis, and relative chlorophyll content has a positive relationship with photosynthetic rate. The decrease in chlorophyll content under climate change has been considered a typical symptom of oxidative stress and may be the result of pigment photo-oxidation and chlorophyll degradation. Decreased chlorophyll level during drought stress has been reported in many species, depending on the duration (Kpyoarissis et al., 1995; Zhang and Kirkham, 1996). Loss of chlorophyll contents under water stress is considered a main cause of inactivation of photosynthesis. Chlorophyll content was measure at different date from the sowing then we observed that the chlorophyll content of normal sowing is greater than the late sowing treatment. The heat stress significantly reduced the chlorophyll content of all the wheat varieties. The maximum chlorophyll content in T1 heat stress was recorded in Raj-3765 followed by K-7903 while lowest chlorophyll content was recorded in K-9644 followed by K-9423.Under T2 heat stress the highest chlorophyll content was recorded in Raj-3765 and lowest in K-9644. So we observed that the Raj-3765 and K-7903 are heat tolerant varieties while rest all the six wheat cultivar are susceptible.

Table-2 Significant effect of late sowing on chlorophyll content of different wheat cultivars

	CONTROL			TREATMENT (T1)			TREATMENT (T2)		
Variety	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll (mg/g)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll (mg/g)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll (mg/g)
K 7903	1.542	0.585	2.14	1.514	0.569	2.08	1.618	0.426	2.05

HUW 234	1.512	0.531	2.06	1.553	0.426	1.99	1.623	0.357	1.96
UP 2425	1.554	0.364	1.92	1.538	0.349	1.89	1.486	0.321	1.82
Raj 3765	1.738	0.563	2.31	1.675	0.521	2.21	1.616	0.457	2.08
K 9644	1.446	0.425	1.88	1.469	0.379	1.85	1.501	0.348	1.80
PBW 373	1.629	0.368	1.99	1.612	0.357	1.97	1.609	0.348	1.95
K-9423	1.484	0.472	1.90	1.455	0.358	1.85	1.589	0.385	1.82
K-65	1.624	0.368	2.05	1.622	0.484	1.96	1.602	0.364	1.91
MEAN	**1.566**	**0.459**	**2.031**	**1.554**	**0.430**	**1.975**	**1.580**	**0.375**	**1.923**
LSD(0.05)	**0.02**	**0.03**	**0.04**	**0.02**	**0.02**	**0.04**	**0.01**	**0.01**	**0.3**
CV%	**4.87**	**18.7**	**5.91**	**4.5**	**16.2**	**5.58**	**3.3**	**10.8**	**4.7**

Proline content

The Data related to proline content of the wheat varieties is presented in Table-3. All wheat varieties showed different concentration of proline content in control as well as heat stress condition. The concentration of proline was taken at different date 30 days,60 days and 90 days from the date of sowing. Proline concentration was low in control as comparison to late sowing condition. The Maximum proline was recorded in K-9644 followed by K-9423 and UP-2425 while minimum proline concentration was recorded in Raj-3765 followed by K-7903. Sankar et al. (2007) reported that high proline accumulation in plants could provide energy for growth and survival and thereby help the plant to tolerate stress. It is now well known that proline accumulation in plant leaf cells, as a compatible solute, plays an important role in regulating water loss from the cells under water deficit and osmotically stressful conditions (Bayoumi et al., 2008).

Table-3 Significant effect of late sowing on Proline content (µg/g fresh wt.) of different wheat cultivars

	CONTROL			**TREATMENT (T1)**			**TREATMENT (T2)**		
Variety	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**
K 7903	0.195	0.365	0.446	0.218	0.385	0.456	0.220	0.393	0.458
HUW 234	0.209	0.398	0.468	0.209	0.408	0.485	0.215	0.412	0.498
UP 2425	0.212	0.378	0.494	0.220	0.405	0.509	0.221	0.409	0.518
Raj 3765	0.201	0.374	0.435	0.219	0.382	0.440	0.224	0.385	0.442
K 9644	0.198	0.397	0.496	0.203	0.417	0.520	0.213	0.418	0.522
PBW 373	0.219	0.407	0.493	0.223	0.427	0.503	0.227	0.430	0.513
K-9423	0.210	0.385	0.498	0.215	0.410	0.512	0.225	0.435	0.520
K-65	0.202	0.395	0.495	0.210	0.418	0.510	0.212	0.420	0.515

MEAN	**0.205**	**0.387**	**0.478**	**0.214**	**0.406**	**0.491**	**0.219**	**0.412**	**0.498**

CONCLUSION

On the present investigation it may be conclude that the grain yield, proline content, chlorophyll content and all the yield components of wheat genotypes were affected by high temperature. Different genotypes showed variable response to high temperature. We observed that Raj-3765 is highly tolerant variety followed by K-7903 under moderate high heat stress. Although, variety UP-2425 gave high yield under controlled condition but it also showed high susceptibility to heat stress in all respect. So we can say that wheat yield, chlorophyll content and proline content can be used for the screening of heat tolerant wheat cultivars.

REFERENCES

Kumar, A and Sengar, R.S. (2013). Effect of delayed sowing on yield and proline content of different wheat cultivars, Research on Crops 14(2):409-415

Kumar, A, Sengar, RS, Singh R, Rani A Shukla G and Girdharwal V. (2015) Screening of heat tolerance wheat germplasm under late seeded condition, Journal of Environmental and Applied Bioresearch 3 (4): 206-210.

Abd El-Monem, AA (2007). Polyamines as modulators of wheat growth, metabolism and reproductive development under high temperature stress. PhD Thesis: Ain Shamas University (Cairo, Egypt).

Ali, G, Iqbal, Z, and Nazir, MS (1982). Grain yield and protein contents of some short duration wheat genotypes in relation to degree of late sowing. J. Agric. Res. Pakistan **20** (**1**): 9-16.

Batts, G R, Morison, J I L, Ellis, R H, Hadley, P and Wheeler T R, (1997). Effect of CO_2 and temperature on growth and yield of crops of winter wheat over four seasons. *European J Agron.* **7:** 43-52.

Bayoumi, M, Eid, H and Metwali, EM, (2008) Application of physiological and biochemical indices as a screening technique for drought tolerance in wheat genotypes. African Journal of Biotechnology **7**: 2341-2352

Gibson, L R, and Paulsen, G M (1999). Yield components of wheat grown under high temperature stress during reproductive growth. *Crop Sc.* **39:** 1841-1846.

Hamam, KA and Khal (2009). Stability of wheat genotypes under different environments and their evaluation under sowing dates and nitrogen fertilizer levels. In: *Australian Journal of Basic and Applied Sciences,* **3(1),** p. 206-217.

IPCC (2014) Climate change 2014. In: Fifth assessment synthesis report (longer report) of intergovernmental panel on climate change. Cambridge University Press, Cambridge, United Kingdom and New York, USA

Karttenberg, A F, Giorgi, H, Grassl, G A, Meehl, J F BMitchll, R J, Stouffer, T, Tokioka, A, Weaver ,J, and Wigley T M L, (*1995).* *Climate models-projection of future climate. In:* Houghton, J. T. ed. "The science of climate change. Contribution of working group I to the second assessment report of the intergovernmental panel on climate change". Cambridge University, Cambridge, pp. 289-357.

Kyparissis, A, Petropoulun, Y and Manetas, Y (1995). Summer survival of leaves in a soft-leaved shrub (*Phlomis fruticosa* L., Labiatae) under Mediterranean field conditions: avoidance of photoinhibitory damage through decreased chlorophyll contents.J. Exp. Bot., **46**: 1825-1831.

McMaster, GS, (1997). Phenology, development, and growth of wheat (*Triticum aestivum* L.) shoot apex: A review. In: *Adv. Agron.*, **59**, p. 63-118.

Melladoz, M. (1980). Effect of sowing dates and nitrogen rates on a spring wheat cultivar. Agriculture Teenia, **40(1):** 7-12

Mostafa, HAM, Hassanein, RA, Khalil, SI, El-Khawas, SA, El-Bassiouny, HMS and Abd El-Monem, AA (2009). Effect of arginine or putrescine on growth, yield and yield components of late sowing wheat. In: *J. of Applied Sci. Res.* (in press).

Ouda, SA, El-Marsafawy, SM, El-Kholy, MA and Gaballah, MS, (2005). Simulating the effect of water stress and different sowing dates on wheat production in South Delta. In: *Journal of Applied Sciences Research*, **1(3),** p. 268-276.

Paulsen, G M (1994). High temperature responses of crop plant. In: "Physiology and determination of crop yield" (ed. by Boote, K. J.). ASA, CSSA, SSSA, Madison, WI, pp. 365-389.

Rajender, K, Surinder, S, Kumar, R and Singh, S (1998). Effect of sowing dates on wheat varieties under late sown irrigated conditions. International J. of tropical Agriculture., **16**:1-4

Rayan, AA, El-Marsafawy, SM and Mohamed, KA, (1999). Response of some wheat varieties to different sowing dates and irrigation regimes in Upper Egypt. In: *3rd Conference of On-Farm Irrigation and Agroclimatology*. SWERI, ARC (Egypt).

Sankar, B, Jaleel, C, Manivannan, P, Kishorekuma, A, Somasundaram, R, Panneerselvan, R (2007) Drought induced biochemical modification and Proline metabolism in Abelmoschus esculentus (L) Moench. Acta. Bot. Croat. **66**: 43-56

Spinks, JH, Semere, T, Sparkes, DL, Wahley, JM, Foulkes, MJ, Calre, RW and Scatt, RK (2000). Effect of sowing dates n planting density of winter wheat. Annals of applied Biology. **137:2**, 179-188

Waraich, SA, Yamin, S and Ashraf, S (1981). Genetic parameters influenced by seeding dates in wheat. Pak Agric. Sci., **4(2):**L273-27.

Wardlaw, I F and Moncur, L (1995). The response of wheat to high temperature following anthesis. I. The rate and duration of kernel filling. *Aust. J. Plant Physiol.* **22:** 39 1-397.

Wheeler, R L, Batts, G R, Ellis, R H, Hadley, P and Morison, J 1 L (1996). The duration and rate of grain growth and harvest index of wheat *(Triticum aestivum)* in response to temperature and CO_2. *J. Expt. Botany* **47:** 623-630.

Zhang, J, and Kirkham, MB (1996). Antioxidant response to drought in sunflower and sorghum seedlings. New Phytol., **132**: 361-373.