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Original Research Article

"Water-use efficiency and transpiration rate of wheat under irrigated and desiccated conditions"

ABSTRACT

Growth and water use were measured in wheat (Triticum aestivum L.) grown in Faculty of life and environmental science, Japan during 2009/10–2010/11 seasons. Water use efficiency was partitioned into transpiration (T) and dry weight difference between booting and maturity, and water-use efficiency (WUE) and transpiration rate (TE) in wheat cultivars (Egyptian Sakha94,Turkish Adana99). were calculated. The aim of the study was to examine the influence of irrigation and nitrogen as ammonium sulphate(NH_4SO_4) at five levels (0.0,75,150,225,300 kg N h^{-1}). on WUE and TE in pots. The results indicated that higher applied nitrogen lead to significantly increase in WUE in both cultivars under irrigated and desiccated conditions. In addition to WUE was significantly higher under desiccated conditions than irrigated conditions in both cultivars. Observed that drought was imposed after anthesis, the primary cause of increased WUE was decreased leaf chlorophyll concentration, photosynthesis rate and stomatal conductance (g_s).

Keywords: ***Wheat, water use efficiency, Chlorophyll content, desiccated condition,*** **Stomatal conductance (g_s).**

INTRODUCTION

Wheat (*Triticum aestivum* L.) is considered to be the first strategic food crop in Egypt. Wheat is the most important grain crop for bread flour and straw crop for livestock feed in EgyptThe demand for wheat is strong currently; this demand is expected to rise by 40–50% from current levels by 2020.

Nitrogen (N), an essential element of the biochemical processes that drives crop production, many times restricts grain yield in wheat grown under field conditions.High soil pH and high temperature cause higher rates of NH_3 volatilization because they increase soil concentrations of NH_3 dissolved in soil water

(NH_3). **(Jones *et al.* 2007)** Ammonium sulfate resists N loss from ammonia volatilization on non-calcareous soils, and therefore does not require incorporation in those soils.

Because of population growth, the per capita share of water has dropped dramatically to less than1000 (˜700) m^3/capita, which, by international standards, is considered the "water poverty limit". The value may even decrease to 584 m^3/capita in the year 2025 **Abd El-Rahman(2009)**.

In Egypt, production is mainly dependent on Irrigation whereas water shortage and low nutrient availability are the main factors limiting the growth of crops in these areas (**Li *et al.*, 2001**) . Fertilizer application has been reported to have a beneficial effect on improving WUE and grain yield of spring wheat (**Zi-Zhen *et al.*, 2004**).

Photosynthetic capacity in wheat crop is the primary component of dry matter productivity (**Ashraf and Bashir, 2003**). The final biological or economic yield can be increased by increasing the rate of photosynthesis, by reducing wasteful respiration or by optimizing assimilate partitioning **(Lawlor, 1995).** Thus, the main objective of this work is to evaluate the effects of N availability on WUE under irrigated and desiccated conditions. .

Materials and Methods

The present study was carried out in Glasshouse in Department of Agriculture, Faculty of Life and Environmental Science, Shimane University, Japan. This investigation is performed during the two winter successive growing seasons 2009/2010 and 2010/2011.

Plant materials: Spring bread wheat cv. Adana99 one of the dominant cultivar from Mediterranean area, Çukurova Agricultural Researches Institute, Adana.

Spring bread wheat cv. Sakha94 was obtained from Field Crops Department, Agricultural Research Centre, Ministry of Agriculture, Giza, Egypt.

Black soils of andosol (volcanic ash soil) for rice seedling (Green soil, Izumo Green co. Izumo, Japan) is filled in the pot that the diameter was 20 cm (314 cm^2) and its depth 1 m. This soil is andosol that is defined by soil science filed and hence analysis of physical property will not be needed.

Nitrogen treatments:-

Nitrogen fertilizer levels (0.0,75,150,225,300 kg N h^{-1}) was applied in three equal doses before the sowing , the tillering and the booting stages.

Irrigation treatment:

Irrigation will be continued for all pots till booting stage near 70% field capacity. After booting irrigation will be withheld to maturity in non temperature controlled glasshouse in ambient CO_2 concentration. From half of pots while for remained pots irrigation will be continued.

Measurements

Dry weight and leaf area

The harvested plants at booting:

(1) Leaf area of each attached leaf position will be separately measured with a leaf area meter.

(2) Leaf and other parts of shoots will be put into 80 ºC oven for 48 h and weigh. Plant parts will be reserved into plastic bag for N analysis.

Total chlorophyll content (SPAD value):

Chlorophyll concentration of flag leaves was determined with a portable chlorophyll meter (SPAD-502, Soil-Plant Analysis Development (SPAD) Section, Minolta Camera, Osaka, Japan) was used to measure **(Castelli *et al*.,1996)**.

Leaf conductance (C_L):

Stomatal conductance (g_s) was measured on fully expanded flag leaves from the abaxial surface as mmol H_2O m^{-2} s^{-1} from three plants in each pot with a dynamic diffusion porometer (Delta-T AP4, Delta-T Devices Ltd, Cambridge, UK) during the middle of the day. Two measurements from both adaxial and abaxial surfaces of the leaf were taken. The porometer was calibrated at the start of each measurement session. It will be measured in the fine days (following weather) every 4 or 7 days from booting till harvest with a porometer. (**Izanloo *et al*. 2008)**.

Measurement in the top leave and front (ra) and back side (rd) of the center of the leaf.

Total leaf conductance (rl) is $1/rl = 1/ra + 1/rb$

Consumptive use and soil water contents :

(1) Soil water contents profile:

Soil water content (*W*s) was measured every 4 days by time domain reflectometry (TDR) from the beginning till the end of the stress period. Readings of soil dielectric constant were converted to a measure of soil water content as described by **Topp and Davis (1985).**

SWC=(-619.2BD+631)TDR reading–64.7BD+74.3(H_2O g cm^{-3}) whereas Soil Bulk Density (BD) = 0.9

Water use efficiency (WUE):

calculated by this Equation

$WUE=(DMI/(T_r/VPD))$

Where, DMI is dry weight difference between booting and maturity, T_r is the transpiration rate [(PWDn-(n-1)+--+PWD1), and VPD is average vapor pressure deficit at day time between booting and maturity .**(Tanner and Sinclair, 1983)**. VPD is measured with a humidimeter and logger for 30 min interval **(Tanner and Sinclair, 1983).** Temperature and humidity will be measured and logged with a temperature and humidity senser and logger before booting stage **(Tanner and Sinclair, 1983).**

4 -Statistical analysis:-

All data collected were subjected to statistical analysis of variance (ANOVA) as described by **Gomez and Gomez (1984)**.The mean values were compared according to Duncan"s Multiple Range Test **(Duncan, 1955).** All statistical analysis were performed using analysis of variance technique by means of “MSTAT-C" computer software package. Significance was determined at $p<0.05$ and means were separated using least significant difference(LSD) and the Tukey test

RESULTS AND DISCUSSIONS

2- Leaf area at anthesis in both season

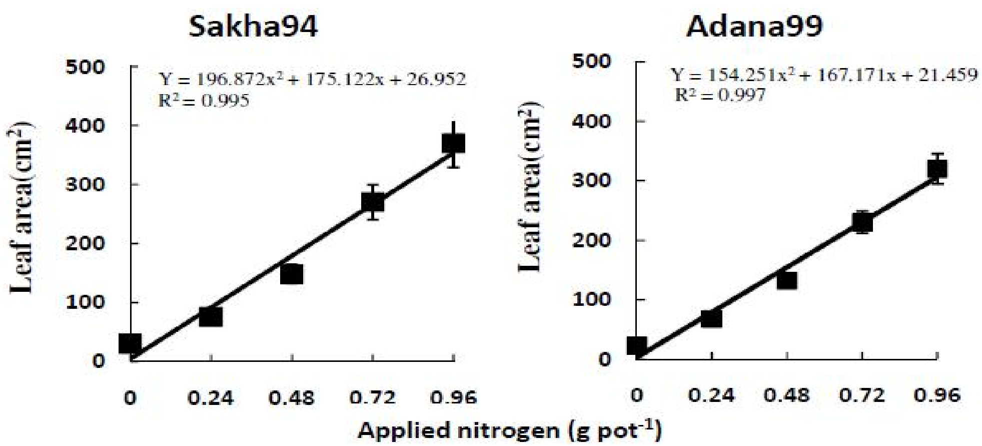

Fig.2. Leaf area (cm^2) at anthesis under different amounts of applied nitrogen fertilizer of ammonium sulfate in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

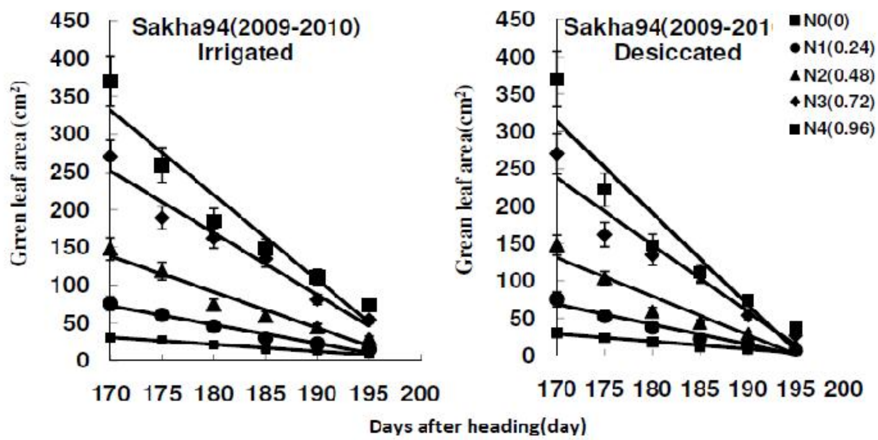

Fig.3. Green leaf area (cm^2) at anthesis under different amounts of applied nitrogen fertilizer of ammonium sulfate in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

3- Shoot and total dry matter production (g pot^{-2}):-

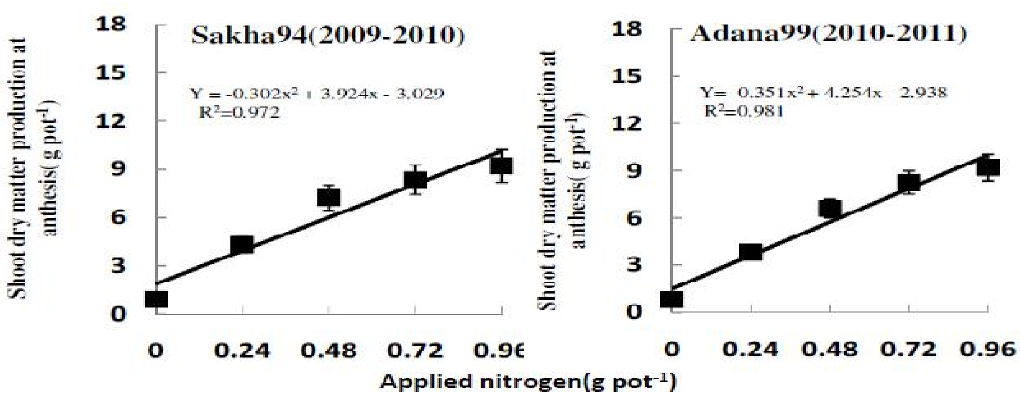

Fig.4. Shoot dry matter production (g pot^{-2}) at anthesis under different amounts of applied nitrogen fertilizer of ammonium sulfate in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

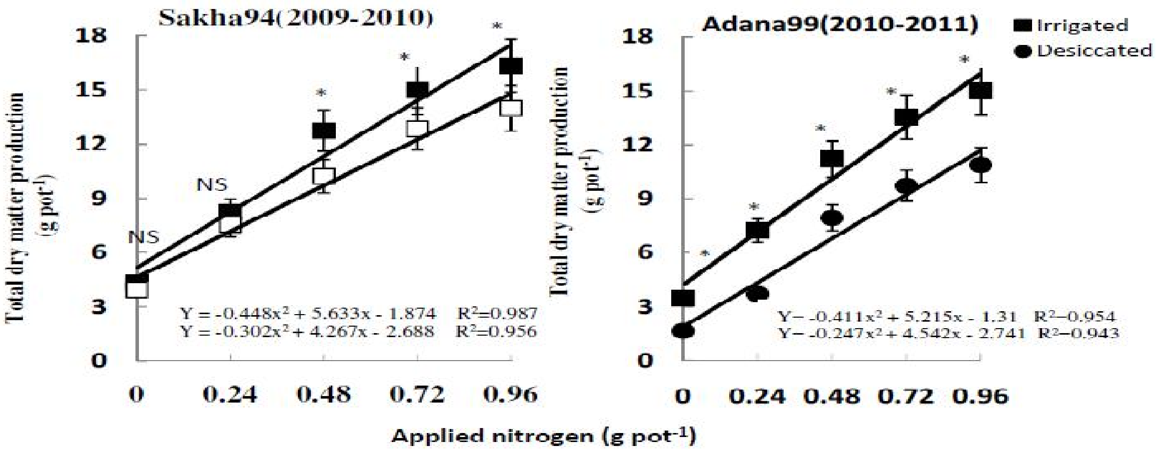

Fig.5. Total dry matter production(g pot^{-2}) after anthesis under different amounts of applied nitrogen fertilizer of ammonium sulfate under irrigated and desiccated conditions in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

4-Spikelet number per spike and Spikelet number per pot under water deficit and irrigated conditions in both seasons.

Spikelet number per spike:-

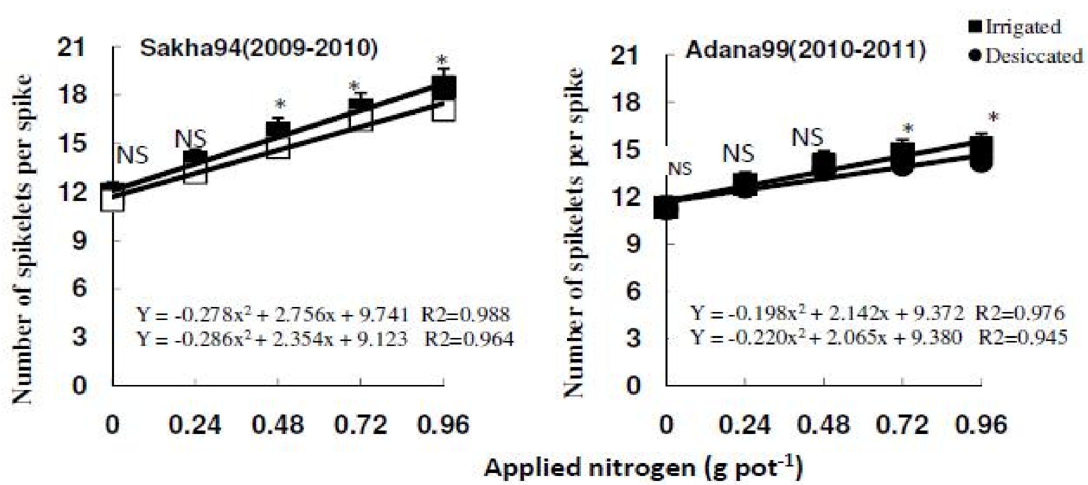

Fig.6. Number of spikelets per spike under different amounts of applied nitrogen fertilizer of ammonium sulfate under irrigated and desiccated conditions in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

Spikelet number per pot:

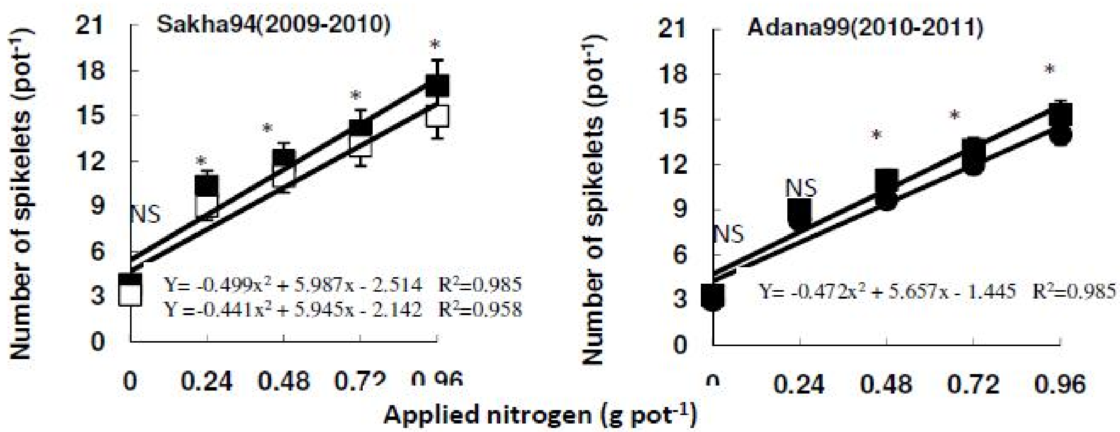

Fig.7. Number of spikelets (pot^{-1}) under different amounts of applied nitrogen fertilizer of ammonium sulfate under irrigated and desiccated conditions in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

5-Spike number per pot water deficit and irrigated conditions in both seasons.

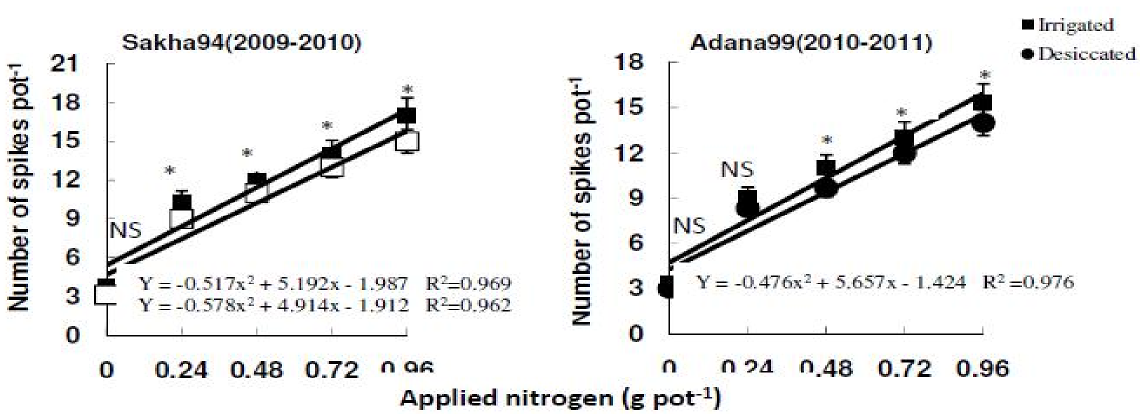

Fig.8. Number of spikes(pot^{-1}) under different amounts of applied nitrogen fertilizer of ammonium sulfate under irrigated and desiccated conditions in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season.Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

6-Leaf chlorophyll concentration (leaf color) at anthesis, and at maturity under water deficit and irrigated conditions in both seasons.

- Leaf chlorophyll concentration (leaf color) before anthesis.

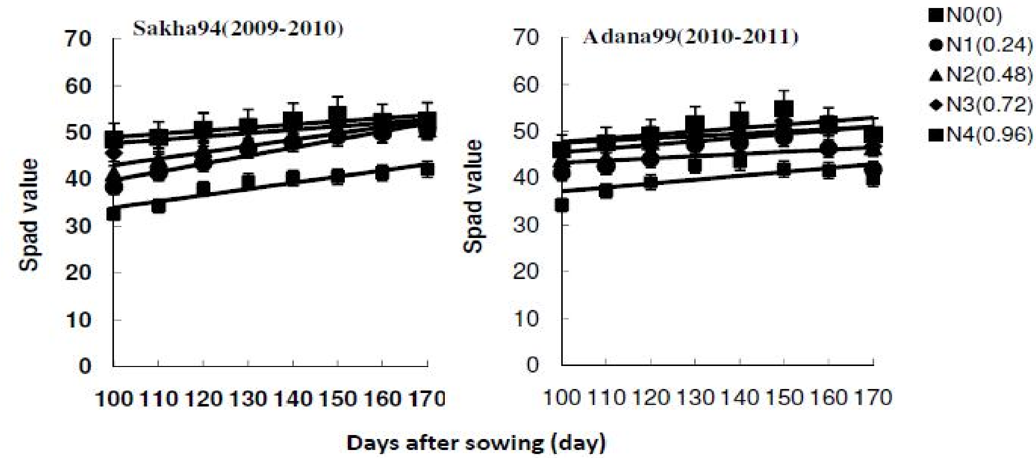

Fig.9. Chlorophyll content(Spad) after days of sowing under different amounts of applied nitrogen fertilizer of ammonium sulfate under irrigated and desiccated conditions in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

- Leaf chlorophyll concentration (leaf color) after anthesis.

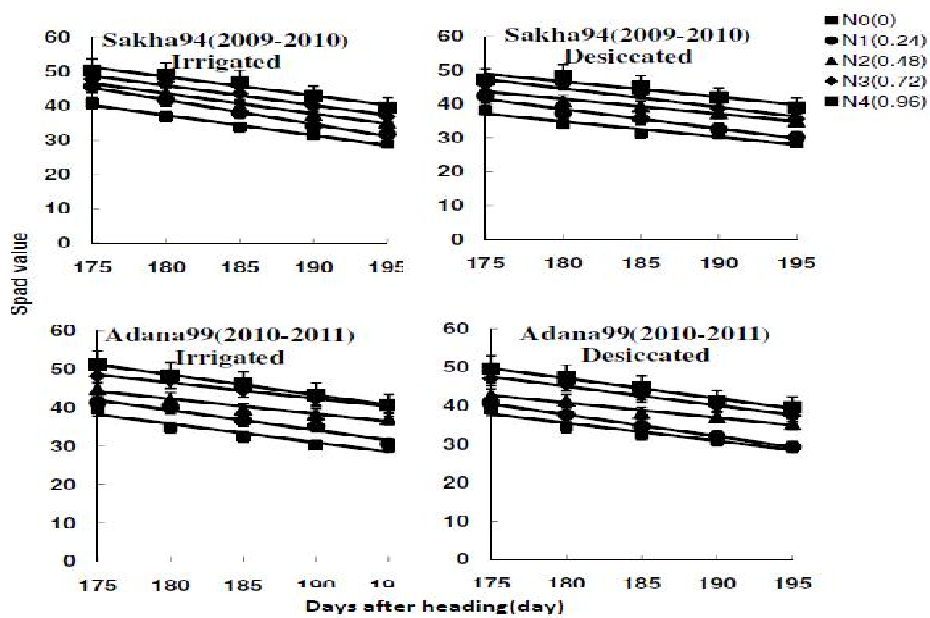

Fig.10. Chlorophyll content(spad) after days of anthesis under different amounts of applied nitrogen fertilizer of ammonium sulfate under irrigated and desiccated conditions in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

7-Stomatal conductance (g_s) in different growth stages after anthesis under water deficit and irrigated conditions in both seasons.

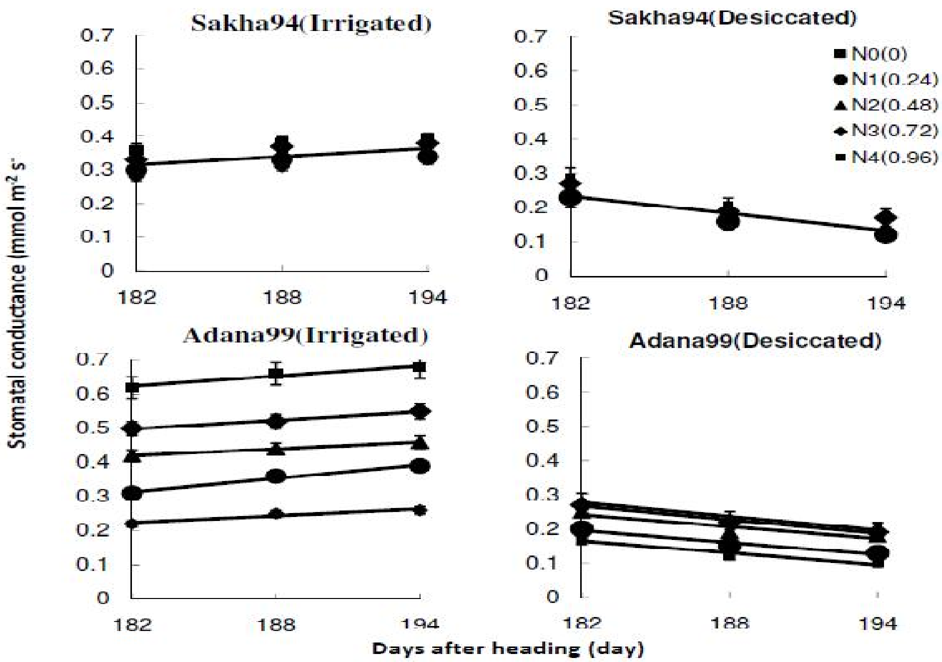

Fig.11. Stomatal conductance(mmol m^{-2} s^{-1}) after days of anthesis under different amounts of applied nitrogen fertilizer of ammonium sulfate under irrigated and desiccated conditions in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify .

10- Transpiration rate (T_r) after anthesis under water deficit and irrigated conditions in both seasons.

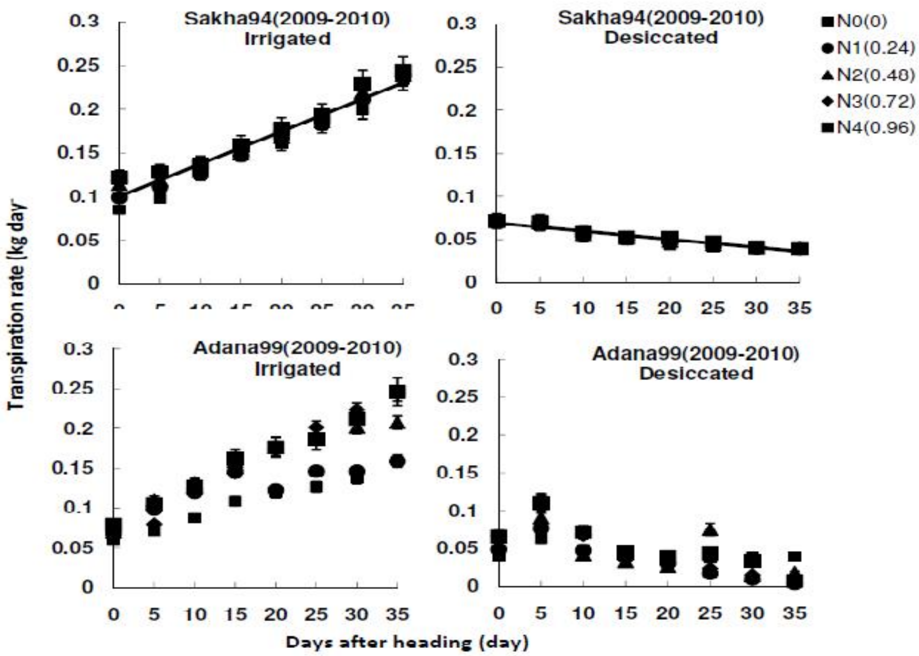

Fig.14. Transpiration rate (kg day^{-1}) after days of anthesis under different amounts of applied nitrogen fertilizer of ammonium sulfate under irrigated and desiccated conditions in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

11-Consumptive use (CU) after anthesis under water deficit and irrigated conditions in both seasons.

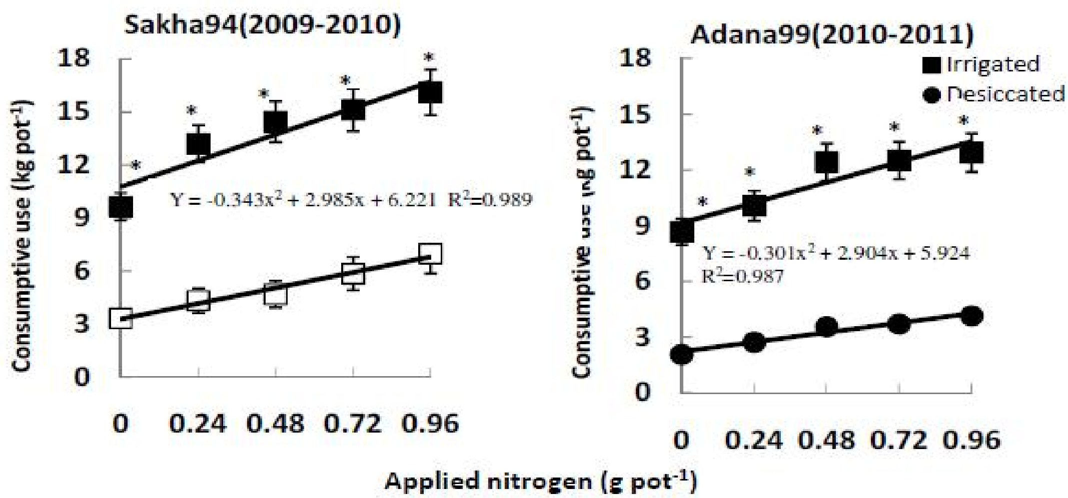

Fig.15. Consumptive use (kg pot^{-1}) under different amounts of applied nitrogen fertilizer of ammonium sulfate under irrigated and desiccated conditions in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

12-Water use efficiency (g kg^{-1}) after anthesis under water deficit and irrigated conditions in both seasons.

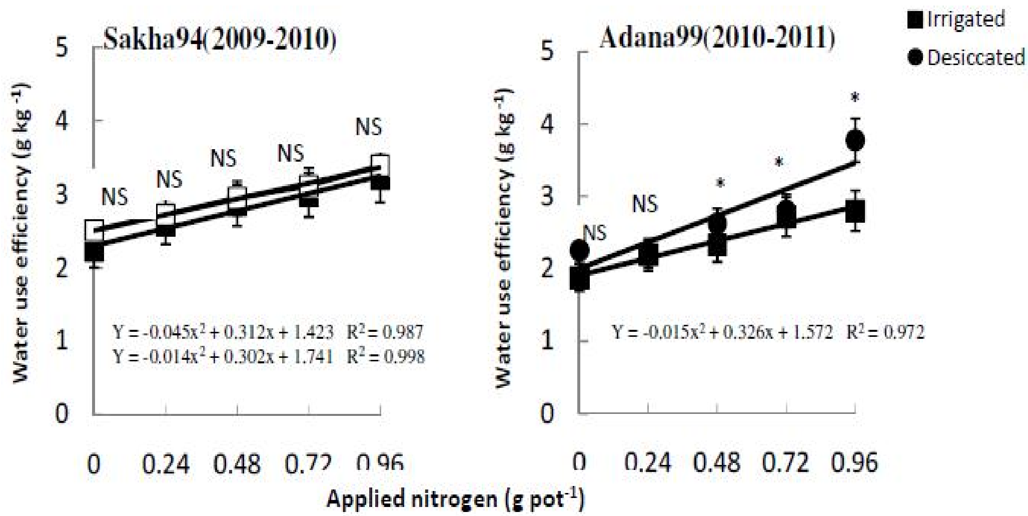

Fig.16. Water use efficiency (g dry matter kg^{-1} water use) under different amounts of applied nitrogen fertilizer of ammonium sulfate under irrigated and desiccated conditions in two (Sakha 94 and Adana99) spring wheat cultivars in 2009-2010 and 2010-2011 season. Each data is mean ± standard error of four replicates. Standard error less than sizes of symbols was omitted for clarify.

CONCLUSION:-

On the basis of these results it can be concluded that higher applied nitrogen lead to significantly increase in WUE in both cultivars under irrigated and desiccated conditions. In addition to WUE was significantly higher under desiccated conditions than irrigated conditions in both cultivars. Observed that drought was imposed after anthesis, the primary cause of increased WUE was decreased leaf chlorophyll concentration, photosynthesis rate and stomatal conductance (g_s).

REFERENCES:-

Abd El-Rahman, G. (2009). Water use efficiency of wheat under drip irrigation systems at Al-Maghara Area, North Sinai, Egypt. American-Eurasian J. Agric. & Environ. Sci., 5 (5): 664-670.

Ashraf, M. and A. Bashir (2003). Relationship of photosynthetic capacity at the vegetative stage and during grain development with grain yield of two hexaploid wheat (*Triticum aestivum* L.) cultivars differing in yield. *Eur. J. Agron*, **19**: 277-287.

Castelli, F; R. Contillo and F. Miceli (1996). Non destructive determination of leaf chlorophyll content in four crop species. J. Agron. and Crop Sci., 177: 275-283.

Duncan, B.D. (1955). Multiple range and multiple F.Test.Biometrics,11:1-42

Gomez, K.A. and A.A. Gomez. (1984). Statistical procedures for agricultural research. Wiley Interscience, New York, 680 p.

Jones, C. A. B.; D. Brown and G. D. Jackson(2007). Management of urea fertilizer to minimize volatilization. A Kansas State University publication by Dr. David Kissel.

Li, F. M., Song, Q. H., Liu, H. S., Li, F. R. and X. L. Liu (2001). Effects of pro-sowing irrigation and phosphorus application on water use and yield of spring wheat under semi-arid conditions. *Agric. Water Manag*. 49: 173–183.

Izanloo, A.; G. Anthony and S. Thorsten (2008). Different mechanisms of adaptation to cyclic water stress in two South Australian bread wheat cultivars. Journal of Experimental Botany, 59, (12):3327–3346.

Lawlor, D. W. (1995). Photosynthesis, Productivity and Environment. *J. Exp. Bot*., **46**: 1449-1461.

Tanner C.B. and Sinclair TR. (1983). Efficient water use in crop production: research or re-search? In: Taylor HM, Jordan WR, Sinclair TR, eds.Limitations to efficient water use in crop production. Madison, WI: American Society of Agronomy,1–27.

Topp, G.C. and J.L. Davis (1985). Time domain reflectometry (TDR) and its application to irrigation scheduling. *In* Advances in Irrigation. Ed. D. Hillel. Academic Press, New York, pp 107–127.

Zi-Zhen, L.; L.Wei-Dea and L.WenLong (2004). Dry-period irrigation and fertilizer application affect water use and yield of spring wheat in semi-arid regions. *Agric. Water Manag.* **65**: 133–143.