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# EVALUATION OF TWO WHEAT VARIETIES UNDER DIFFERENT MOISTURE STRESS AND NITROGEN FERTILIZATION

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## ABSTRACT

*Two field experiments were conducted at the Experimental Station of Faculty of Agriculture (Saba–Basha) Alexandria University, Alexandria Governorate during 99/2000 and 2000/2001 seasons. The main objective was to study the influence of moisture stress imposed during some growth stages and nitrogen levels on wheat physiology and yield. A split-spilt plot design with three replications was used. Five irrigation treatments (W1= full irrigation, W2= stress at vegetative stage W3= stress at flowering stage, W4= stress at grain filling stage and W5= rain fed treatment) were assigned to the main plots, four nitrogen levels (No= 0, N1=83, N3= 166 and N4= 250 kg N/ha) were allocated to the sub-plots. While both cultivars (Sakha 69 and Sahel 1) occupied the sub-sub plots. Results indicated that moisture stress imposed at the different growth stages reduced significantly leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) and chlorophyll contents. There was positive correlation between grain yield and LAI, CGR, RGR and NAR in both seasons. However, increasing N levels from zero up to 250 kg N/ha increased significantly these traits in both seasons. Sakha 69 cultivar exceeds Sahel 1 in most of these traits. Generally, when it is needed to save considerable amount of water of wheat cultivars under study without big reduction in these traits, skipping an irrigation at grain filling stage my be practiced, providing that temperature and wind velocity are not great and with moderate relative humidity.*

Key words: *Wheat, Moisture stress, Growth stages, Nitrogen levels*

## INTRODUTION

Wheat (*Triticum aestivum* L.) is the most important and most widely cultivated cereal crop in the world. Its importance derived from many properties and uses of its kernels, which make it a stable food for more than one-third of the world population (Sabry *et al* 1999).

Drought continues to be a challenge to agricultural scientists, despite many decades of research. The impact of drought could be more accurately predicated with a clear picture of the relationships between growth stage and plant response to stress. The optimum timing and dose of fertilizer and irrigation applications are also best determined by crop growth stage rather than calendar date.

The magnitude of yield reduction from water deficits in wheat depends upon the growth stage at which the water deficiency occurs and the severity and duration of the deficiency.

Literature on "moisture-sensitive stages" suggests that wheat has stages in its development, which are not equally sensitive to water stress. Internodes elongation and heading stages of growth are particularly sensitive to water stress (Salter and Goode 1967). The crown root initiation, flowering and dough were the critical growth stages in the life cycle of dwarf wheat (Misra *et al* 1969). Moisture stress in the vegetative period reduced the number of tillers, while irrigation after soft dough did not increase yield as mentioned by Chauhan *et al* (1970). Water stress during boot and heading stages limits yield potential without compensation when water stress is relieved.

Fertilization and water are codependent management factors that may not be completely evaluated as independent factors, as has been predominant in past research. A number of studies (Campbell *et al* 1993, Moustafa *et al* 1997 and Abd El-Monem 1999) have measured crop yields, fertilizer use efficiency parameters and water use efficiency under different levels of fertilization and irrigation water. However, none of these studies used both crop yield and fertilizer use efficiency parameters to study the interaction of optimum rate of chemical fertilizer and scheduling of irrigation water. Therefore, the objectives of this study were:

To study the physiological response of some wheat cultivars to moisture stress imposed at the different growth stages under nitrogen fertilization levels.

To measure the effect of drought and nitrogen fertilization on growth, development traits, yield and yield components of two wheat cultivars.

## MATERIALS AND METHODS

Two field experiments were conducted during the two winter seasons of 99/2000 and 2000/2001 at the experimental station of Faculty of Agriculture (Saba-Basha) Alexandria University, Alexandria, Egypt. The soil texture of the experimental site was clay in both seasons. Detailed data of the soil type characteristics and meteorological data of Alexandria Governorate are presented in Tables (1) and (2) respectively.

Table 1. Physical and chemical properties of the soil for the experimental sites during both seasons.

| Season | Season 99/2000 | Season 2000/2001 |
|---|---|---|
| **Properties** | | |
| **Physical properties** | | |
| Clay % | 49.0 | 48.0 |
| Silt % | 15.0 | 13.3 |
| Sand % | 36.0 | 38.7 |
| Soil texture | clay | clay |
| **Chemical properties** | | |
| pH | 8.25 | 8.61 |
| E.C (ds/m) | 4.1 | 3.6 |
| $Caco_3$ | 15.7 | 16.6 |
| Organic matter % | 2.2 | 1.8 |
| Total nitrogen % | 0.16 | 0.09 |
| **Soluble cations meq/100 g soil** | | |
| Ca | 0.88 | 0.82 |
| Mg | 0.69 | 0.65 |
| Na | 2.8 | 2.62 |
| K | 1.41 | 1.35 |
| **Soluble cations meq/100 g soil** | | |
| $Hco_3$ | 2.5 | 2.35 |
| Cl | 2.92 | 2.90 |
| $So_4$ | 0.37 | 0.15 |

These analyses were carried out at the soil department laboratory, Faculty of Agriculture (Saba Basha), Alexandria University.

Table 2. The meteorological data per month in Alexandria for 99/2000 and 2000/2001 seasons*.

| Month | 99/2000 | | | | | 2000/2001 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Max Tc⁰ | Min Tc⁰ | Ra (mm) | Mean Rh% | U2 m/sec | Max Tc⁰ | Min Tc⁰ | Ra (mm) | Mean Rh% | U2 m/sec |
| November | 24.5 | 15.9 | 6.6 | 58 | 3.39 | 22.1 | 12.6 | 31.5 | 76 | 3.40 |
| December | 21.3 | 10.9 | 15 | 70 | 2.34 | 23.3 | 11.5 | 45 | 71 | 2.34 |
| January | 16.7 | 9.8 | 92.1 | 70 | 3.14 | 14.9 | 9.3 | 42 | 65 | 3.14 |
| February | 17.7 | 8.7 | 19.2 | 61 | 2.91 | 20.1 | 8.9 | 19 | 63 | 2.91 |
| March | 19.1 | 9.4 | 8.7 | 60 | 2.96 | 22.8 | 12.9 | 1.2 | 70 | 2.96 |
| April | 24.9 | 14.2 | 0.7 | 61 | 3.03 | 24.3 | 13.6 | 0.7 | 64 | 3.25 |

*These data were obtained from the meteorological station at Kobba, Cairo, Egypt.
Max = maximum temperature $c^0$, Min = minimum temperature $c^0$, Ra = rain fall (mm), Rh = relative humidity %, $U_2$ = wind speed m/second

A split-split plot design with three replications was used. The main plots were devoted to five moisture stress treatments (missing one irrigation at vegetative stage; missing one irrigation at flowering stage; missing one irrigation at grain filling stage; a severe water stress treatment (rainfall only); and without missing any irrigation (Table 3). The sub-plots were assigned to four nitrogen levels (0, 83, 166 and 250 kg N/ha) in the form of (46% N). The sub-sub plots were occupied by two wheat cultivars (Sakha 69 and Sahel 1).

**Table 3. Moisture regime treatments.**

| Treatments | Plant stages at which plants were water stressed | | |
|---|---|---|---|
| | Vegetative stage | Flowering stage | Grain filling stage |
| W1 | Watered | Watered | Watered |
| W2 | Water stress | Watered | Watered |
| W3 | Watered | Water stress | Watered |
| W4 | Watered | Watered | Water stress |
| W5 | Water stress | Water stress | Water stress |

The experimental plot was 10.5 $m^2$ (3.0x3.5m). Wheat cultivars were sown by broadcasting on the third week of November in both seasons at the rate of 143 kg seeds/ha. Cultural practices were applied for wheat as recommended in the region. Phosphorous fertilizer in the form of super phosphate (15.5% $P_2O_5$) was applied during the preparation of the soil at the rate of 238 kg/ha, whereas N fertilization was applied in two equal portions: at sowing and before the first irrigation. All plots were irrigated just after planting (30 days after sowing). The moisture stress treatments were imposed by missing irrigation at the previous mentioned different growth stages.

Plant samples from sub-sub plots were collected and measured after 98, 118 and 138 days after sowing (DAS) to estimate, leaf area index (LAI) crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) according to the methods described by Franklin *et al* (1985). Chlorophyll was extracted from leaves (0.5 g sample was taken in 15 ml 80% acetone and kept in the refrigerator for 24h). Then the sample was filtered and absorption values of filtrate were read using SD- 100 ultraviolet and visible spectrophotometer (pye Inc. comp. Ltd) at 663 and 645nm. Chlorophyll (a), (b) and total chlorophyll were calculated using the formula of Bonner and Varner (1965). At harvest number of spikes /$m^2$, number of kernels/spike, 1000-kernel weight and grain yield (t/ha) were calculated.

All the data were statistically analyzed according to Steel and Torrie (1982) and least significant difference at 0.05 level of significance was used for comparing the treatment means.

## RESULTS AND DISCUSSION

### Growth analysis parameters

### Leaf area index (LAI)

Means of LAI as presented in Table (4) revealed that significant reductions were caused by moisture stress imposed at the different growth stages when measured at both growth intervals $A_1$ (98-118) and $A_2$ (119-138 days) after sowing in both seasons, except at grain filling stage at ($A_1$) in the second season. The amount of reduction was 13, 12, 6 and 21% in the first season, whereas in the second season it was 17, 9, 2, and 25% when plants were subjected to water stress at vegetative, flowering, grain filling stages and at severe water stress, respectively. This might be due to reduction in number of cells through cell division and/or reduction in cell size through cell enlargement and turgidity. Similar results were reported by Abd El-Gawad *et al* (1993) and Misra *et al* (1998).

Concerning the nitrogen effect on LAI , increasing N level up to 250 kg/ha significantly increased LAI when measured at both growth intervals in the two seasons Table (4). The progress in LAI could be explained by the nitrogen effect on the number of tillers/$m^2$ and due to the nitrogen stimulation on leaf size. These results are in harmony with those reported by Frederick (1997) and Sabry *et al* (1999).

### Relative Growth Rate (RGR)

Data in Table (4) revealed that subjecting wheat plants to water stress at the vegetative stage and at severe water stress significantly decreased RGR when measured at $A_1$ (98-118) and at $A_2$ (119-138) DAS in both seasons.

With regard to the effect of nitrogen, it was observed that RGR increased significantly as a result of increasing N rate up to 166 kg N/ha when measured at growth interval A1 in the first season. Additional increments above this level did not result in a significant increase in RGR. Similar results were reported by Omar and Abou-Bakr (1995) and Gaafar (1997). On the other hand, there was a significant increase in RGR by increasing N application up to 250kg N/ha at both growth intervals in the second season.

Moisture regimes and N levels had a significant interaction on RGR when measured at growth interval $A_1$ and $A_1$ and $A_2$ in 99/2000 and 2000/2001 seasons, respectively.

Table 4. Means of leaf area index (LAI) and relative growth rate (RGR) of two wheat cultivars grown under different moisture regimes and nitrogen levels in 99/2000 and 2000/2001growing seasons.

| Traits | LAI | | | | RGR (g/g day) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | 99/2000 | | 2000/2001 | | 99/2000 | | 2000/2001 | |
| | $A_1$ | $A_2$ | A1 | A2 | A1 | A2 | A1 | A2 |
| Moisture regimes ( A) Non-stress | 5.08a | 4.17a | 4.52a | 3.82a | 0.034a | 0.021a | 0.033a | 0.021a |
| Stress at vegetative stage | 4.32c | 3.70c | 3.73c | 3.16d | 0.025b | 0.020a | 0.021b | 0.017c |
| Stress at flowering stage | 4.51c | 3.67c | 4.21b | 3.34c | 0.035a | 0.021a | 0.032a | 0.018b |
| Stress at grain filling stage | 4.82b | 3.86b | 4.57a | 3.62b | 0.035a | 0.018a | 0.032a | 0.018b |
| Severe stress | 4.03d | 3.26d | 3.49d | 2.75e | 0.020c | 0.012b | 0.021b | 0.011d |
| Nitrogen fertilizer (B) 0.0 kg N/ha | 2.70d | 2.17d | 2.95d | 2.28d | 0.025b | 0.016b | 0.023c | 0.014d |
| 83 kg N/ha | 4.43c | 3.55c | 4.05c | 3.23c | 0.027b | 0.015b | 0.024c | 0.017c |
| 166 kg/ N ha | 5.32b | 4.36b | 4.46b | 3.69b | 0.032a | 0.019b | 0.031b | 0.018b |
| 250 kg/ N ha | 5.75a | 4.86a | 4.95a | 4.15a | 0.035a | 0.024a | 0.034a | 0.020a |
| Cultivars (C) Sahel 1 | 4.49b | 3.66b | 4.03b | 3.25b | 0.030a | 0.019a | 0.028a | 0.017b |
| Sakha 69 | 4.62a | 3.81a | 4.18a | 3.43a | 0.030a | 0.018a | 0.029a | 0.018a |
| *Interactions* A X B | N.S | N.S | ** | ** | ** | N.S | ** | ** |
| A X C | N.S | N.S | ** | ** | N.S | N.S | N.S | N.S |
| B X C | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S |
| A X B X C | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S |

Means within a column followed by the same letter for each treatment do not differ at the 0.05 probability level.

** Significant at the 0.01 level of probability.

NS= Not significant

$A_1$ = (98-118 days after sowing)

$A_2$ = (119- 138 days after sowing)

It is clear that RGR decreased steadily with time. This might be as a result of leaves senescence and decline of leaf area that could be explained by the reduction of leaf weight in total plant weight. This interpretation is in agreement with those stated by Spitters and Kramer (1986). It could concluded that LAI and CGR could be recommended as a selection criteria for grain yield breeding programmes.

**Crop growth rate (CGR)**

As presented in Table (5) water stress significantly reduced CGR $g/m^2$ /day (except when water stress was imposed at grain filling stage at growth interval $A_1$ in both seasons) as compared to the non-stressed wheat plants. The highest negative response of CGR as affected by missing irrigation was clearly obtained at severe water stress treatment followed by stress at vegetative stage at the two growth intervals in both seasons. This might be attributed to lower LAI which lowered light interception that, obviously decreased the total dry matter of wheat plants under water stress condition Rahman *et al* (2000) and Pandey *et al* (2001)

Table 5. Means of crop growth rate (CGR) $g/m^{2}/day$ and net assimilation rate (NAR) $(g/m^2/day)$ of two wheat cultivars grown under different moisture regimes and nitrogen levels in 99/2000 and 2000/2001 growing seasons.

| Traits | CGR | | | | NAR | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | 99/2000 | | 2000/2001 | | 99/2000 | | 2000/2001 | |
| | $A_1$ | $A_2$ | A1 | A2 | A1 | A2 | A1 | A2 |
| Moisture regimes ( A)<br>Non-stress | 15.06 a | 11.18 a | 13.90 a | 10.74a | 3.02 a | 2.69 a | 3.11 a | 2.82 a |
| Stress at vegetative stage | 10.44 c | 8.11 b | 9.63 c | 7.14 d | 2.29 b | 2.16 b | 2.55 c | 2.20 c |
| Stress at flowering stage | 12.54b | 9.00 b | 11.73 b | 8.14 c | 2.99 a | 2.45 b | 2.75 bc | 2.37 b |
| Stress at grain filling stage | 15.31 a | 9.24 b | 13.50 a | 9.20 b | 3.25 a | 2.32 ab | 2.94 bc | 2.47 b |
| Severe stress | 6.78 d | 4.07 c | 7.20 d | 3.71 e | 1.64 c | 1.28 c | 1.96 d | 1.32 d |
| Nitrogen fertilizer (B)<br>0.0 kg N/ha | 7.81 d | 4.68 d | 7.31 d | 4.32 d | 2.83 a | 2.14 ab | 2.43 b | 1.86 c |
| 83 kg N/ha | 10.57 c | 7.38 c | 9.18 c | 6.89 c | 2.38 b | 2.05 b | 2.21 c | 2.07 b |
| 166 kg/ N ha | 13.57b | 9.57 b | 12.97 b | 9.00 b | 2.52 b | 2.16 ab | 2.91 a | 2.42 a |
| 250 kg/ N ha | 16.14 a | 11.65 a | 15.31 a | 10.92a | 2.82 a | 2.37 a | 3.08 a | 2.59 a |
| Cultivars (C)<br>Sahel 1 | 11.88 a | 8.16 a | 10.86 b | 7.60 b | 2.64 a | 2.20 a | 2.68 a | 2.25 a |
| Sakha 69 | 12.17 a | 8.47 a | 11.52 a | 7.98 a | 2.63 a | 2.16 a | 2.63 a | 2.22 a |
| *Interactions*<br>A X B | N.S | ** | N.S | ** | N.S | N.S | ** | ** |
| A X C | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S |
| B X C | N.S | N.S | ** | ** | N.S | N.S | N.S | N.S |
| A X B X C | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S |

Means within a column followed by the same letter for each treatment do not differ at the 0.05 probability level.

** Significant at the 0.01 level of probability.

NS= Not significant

$A_1$ = (98-118 days after sowing)

$A_2$ = (119- 138 days after sowing)

Significant difference was observed among the cultivars, Sakha 69 had higher CGR than Sahel 1 in the second season. This difference did not appear in the first season. It might be due to gene-environment interaction.

It is clear that, CGR began to decrease as the wheat plants mature. This might be due to cessation of vegetative growth loss of leaves and senescence and this was true and clear when the water stress was severe. Similar results were found by Karimi and Siddique (1991) and Sabry *et al* (1999).

## Net assimilation rate (NAR)

Results in Table (5) illustrate that NAR $g/m^2$ /day when measured at both growth intervals $A_1$ and $A_2$ in both seasons decreased significantly by exposing wheat plants to severe water stress treatment and to water stress at vegetative stage. Such decrease in NAR might be due to the great need for water during the vegetative stage of plant growth. NAR values were steadily increased with increasing N rate from 83 up to 250 kg N/ha when measured at both growth intervals in both seasons. Similar results were recorded by Rao and Bharduaj (1981). The interaction between moisture regimes and N fertilizer levels was significant on NAR in the second season.

## Chlorophyll determination

Total chlorophyll and chlorophyll "a" and "b" (mg/g/ fresh weight) decreased significantly when plants were subjected to water stress (Table 6). The reduction in total chlorophyll was 56.89, 37.10, 21.62 and 7.46% in 99/2000 season, while in 2000/2001 season was 57.70, 36.43, 20.13 and 10.04% when water stress was imposed at severe stress, at flowering, vegetative, and grain filling stages, respectively. The lower concentration of chlorophyll under water stress conditions might be attributed to low rate of synthesizing phytocrome under such conditions (Abd El-Gawad *et al* 1995).

Increasing nitrogen rates up to 250 kg N/ha resulted in remarkable significant increase in chlorophyll "a", "b" and total chlorophyll. Fertilizing wheat with 250 kg N/ha attained the highest value of these traits in both seasons. Such effect of N fertilization on chlorophyll could be attributed to high nitrogen doses enhancing formation of chlorophyll at more rapid rate than the other constituents of the cells. Pandey *et al* (2001) came to the same conclusion. Non-stressed plants with application of 250 kg N/ha produced the highest value of these traits.

## Growth analysis parameters and grain yield correlation

Table (7) indicated that grain yield (t/ha) was strongly positively associated (0.96 & 0.93) with LAI in 99/2000 and 2000/2001 seasons, respectively; positively moderately associated with RGR in both seasons; strongly positively correlated with CGR in both seasons too and moderately and weekly positively correlated with NAR in 99/2000 and 2000/2001 seasons, respectively.

Table 6. Means of chlorophyll "a", chlorophyll "b" and total chlorophyll (mg/g/fresh) weight of two wheat cultivars grown under different moisture regimes and nitrogen levels in 99/2000 and 2000/2001 growing seasons.

| .Traits | Chlorophyll "a" | | Chlorophyll "b" | | Total chlorophyll | |
|---|---|---|---|---|---|---|
| Seasons / Treatments | 99/2000 | 2000/2001 | 99/2000 | 2000/2001 | 99/2000 | 2000/2001 |
| Moisture regimes ( A) | | | | | | |
| Non-stress | 14.86 a | 14.25 a | 7.42 a | 6.86 a | 22.24 a | 21.11 a |
| Stress at vegetative stage | 11.66 c | 11.21 c | 6.10 b | 5.78 b | 17.43 c | 16.86 c |
| Stress at flowering stage | 9.44 d | 9.11 d | 4.56 c | 4.32 c | 13.99 d | 13.42 d |
| Stress at grain filling stage | 14.23 b | 13.07 b | 6.43 b | 5.87 b | 20.58 b | 18.99 b |
| Severe stress | 6.48 e | 6.07 c | 3.13 d | 2.88 d | 9.59 d | 8.93 e |
| Nitrogen fertilizer (B) | | | | | | |
| 0.0 kg N/ha | 4.91 d | 4.49 d | 2.60 d | 2.38 d | 7.51 d | 6.78 d |
| 83 kg N/ha | 9.20 c | 8.30 c | 4.09 c | 3.91 c | 13.17 c | 12.33 c |
| 166 kg/ N ha | 12.54 b | 12.09 b | 6.40 b | 5.92 b | 18.94 b | 18.00 b |
| 250 kg/ N ha | 18.68 a | 18.09 a | 9.02 a | 8.36 a | 27.44 a | 26.44 a |
| Cultivars (C) | | | | | | |
| Sahel 1 | 11.15 b | 10.42 b | 5.33 b | 4.92 b | 16.46 b | 15.35 b |
| Sakha 69 | 11.52 a | 11.06 a | 5.72 a | 5.6 a | 17.07 a | 16.37 a |
| *Interactions* | | | | | | |
| A X B | N.S | N.S | N.S | N.S | N.S | N.S |
| A X C | N.S | N.S | N.S | N.S | N.S | N.S |
| B X C | N.S | N.S | N.S | N.S | N.S | N.S |
| A X B X C | N.S | N.S | N.S | N.S | N.S | N.S |

Means within a column followed by the same letter for each treatment do not differ at the 0.05 probability level.
** Significant at the 0.01 level of probability.
NS= Not significant

Table 7. Simple correlation coefficients between grain yield, LAI, RGR (g /g week), CGR and NAR (g /m$^2$ /day) of wheat grown under different moisture regimes and nitrogen levels in 99/2000 and 2000-2001 growing seasons .

| Character | 99/2000 | | | | 2000/2001 | | | |
|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 2 | 3 | 4 | 5 |
| 1-grain yield t/ha | 0.96** | 0.50** | 0.81** | 0.26* | 0.93** | 0.47** | 0.80** | 0.48** |
| 2- LAI | | 0.48** | 0.78** | 0.17* | | 0.46** | 0.64** | 0.65** |
| 3-RGR g/g/week | | | 0.75** | 0.66** | | | 0.58** | 0.55** |
| 4-CGR g/m$^2$/day | | | | 0.72** | | | | 0.66** |
| NAR g/m$^2$/day | | | | | | | | |

*, **: Significant at the 0.05 and 0.01levels, respectively.

LAI values were highly significantly and positively correlated with RGR and CGR in both seasons, whereas, NAR was significantly and highly significantly correlated with LAI in 99/2000 and 2000/2001 growing seasons. LAI was moderately associated with RGR (0.48 & 0.46) highly and moderately correlated with CGR (078 & 0.64) in 99/2000 and 2000/2001 seasons; and weekly and moderately positively correlated with NAR in 99/2000 and 2000/2001 seasons.

**Yield and yield components**

**Number of spikes/m$^2$**

The presented data in (Table 8) indicated that number of spikes/m$^2$ was reduced significantly as a result of moisture regime treatments imposed at severe water stress and at vegetative stage in both seasons. Whereas, skipping irrigation at flowering stage showed significant reduction in number of spikes/m$^2$ only in 99/2000 season compared with non-stressed plants. Such response may be attributes to lack of water absorbed and reduction in photosynthetic efficiency under insufficient water condition. Moreover, the reduction in assimilates translocated to new developing tillers might owe much to the death of the new tillers and depressing the number of spike primordial. Eck (1988) and Kandil *et al* (2001) came to the same conclusion.

With respect to the nitrogen fertilizer effect, generally results indicated that increasing N level up to 250 kg N/ha led to significant remarkable increase in number of spikes/m$^2$ in both seasons.

The difference among cultivars in number of spikes/m$^2$ was significant only in first season. Sakha 69 had more spikes/m$^2$ than Sahel 1.

**Number of kernels / spike**

Number of kernels / spike was decreased significantly by inducing water stress at the different growth stages (Table 8), except when water stress occurred at grain filling stage where the reduction was insignificant in both seasons. This reduction in number of kernels / spike might be attributed to the reduction in photosynthetic efficiency and the lack of photosynthates translocated to the developing seeds. Abd El-Moniem (1999) and Mahgoub and Sayed (2001) came to the same conclusion.

Table 8. Means of number of spikes/m$^2$ and kernels/spike, 1000-kernel weight and grain yield/ha of two wheat cultivars grown under different moisture regimes and nitrogen levels in 99/2000 and 2000/2001 growing seasons.

| Traits | No. .of spikes /m$^2$ | | No. .of kernels /spike | | 1000-kernel weight (g) | | Grain yield t/ha | |
|---|---|---|---|---|---|---|---|---|
| Seasons / Treatments | 1999/ 2000 | 2000/ 2001 | 1999/ 2000 | 2000/ 2001 | 1999/ 2000 | 2000/ 2001 | 1999/ 2000 | 2000/ 2001 |
| Moisture regimes ( A) Non-stress | 462.50a | 422.46a | 52.17 a | 51.48a | 47.15a | 46.23a | 4.95a | 4.78a |
| Stress at vegetative stage | 415.37b | 385.21b c | 43.88b | 40.96c | 42.65 d | 43.00 c | 4.05d | 3.81d |
| Stress at flowering stage | 419.00b | 397.63a b | 43.25 b | 42.28b | 44.28c c | 43.66bc | 4.21c | 4.07c |
| Stress at grain filling stage | 452.12a | 424.38 a | 51.59 a | 50.90a | 45.25 b | 44.32 b | 4.57b | 4.53b |
| Severe stress | 376.75c | 364.71 c | 37.47 c | 36.87d | 39.27 e | 38.35d | 3.37e | 3.15e |
| Nitrogen fertilizer (B) 0.0 kg N/ha | 330.10d | 343.97 c | 40.18 d | 39.44d | 39.75 d | 39.05 d | 2.18d | 2.08d |
| 83 kg N/ha | 424.80c | 419.87 b | 45.11 c | 44.12c | 43.38 c | 42.37c | 4.08c | 4.11c |
| 166 kg/ N ha | 459.53b | 446.03 a | 47.52b | 46.36b | 44.75b | 44.48b | 5.09b | 4.85b |
| 250 kg/ N ha | 481.17a | 463.37 a | 49.88 a | 48.08a | 47.00a | 46.55a | 5.57a | 5.22a |
| Cultivars (C) Sahel 1 | 418.85b | 413.13 a | 45.53 a | 44.21b | 43.51a | 43.32a | 4.17b | 3.95b |
| Sakha 69 | 431.45a | 423.80 a | 45.82 a | 44.79a | 43.93a | 42.90a | 4.29a | 4.18a |
| *Interactions* A X B | N.S | N.S | ** | ** | * | N.S | ** | ** |
| A X C | N.S | N.S | N.S | N.S | N.S | N.S | * | N.S |
| B X C | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S |
| A X B X C | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S |

**Means within a column followed by the same letter for each treatment do not differ at the 0.05 probability level.**
**** Significant at the 0.01 level of probability.**
**NS= Not significant**

Increasing N rates up to 250 kg N / ha resulted in remarkable significant increase in number of kernels / spike. The increase percentages reached 12.3, 18.3, and 24.1 % in 99/2000 and 11.9, 17.5 and 21.9 % in 2000/2001 season as a result of increasing N levels from zero to 83, 166 and 250 kg N /ha, respectively. The obtained results could be attributed to the role of N in spike fertility and grain development. Bruckner and Morey (1988) and Iskandar (2000) reported similar results. Significant interaction was recorded among moisture regimes and nitrogen rates on number of kernels / spike in both seasons. Non-stressed plants fertilized with 250 kg N / ha gave the greatest value of this trait.

## 1000-kernel weight

Exposing wheat plants to drought at the different growth stages caused a significant reduction in this trait. The highest reduction was recorded when plants exposed to severe stress followed by vegetative, flowering and grain filling stages, respectively, in both seasons (Table 8). This reduction owe much to water deficits, which reduce available assimilates for grain filling. These results confirm those reported by Okuyama (1990) and Osman *et al* (1996).

Raising N level from zero up to 250 kg N /ha led to significant increase in 1000-kernel weight, which showed it's significant values when wheat plants were fertilized with 250 kg N/ha, followed by 166, 83 kg N/ha in both seasons. This finding is logically expected as N element encourages vegetative growth and increases plant capacity in building metabolites. Abdul Galil *et al* (1997) found similar results.

## Grain yield

Grain yield (t/ha) was decreased significantly due to exposing wheat plants to water stress at the different growth stages (Table 8) in both seasons. This reduction in grain yield was 32, 18, 15 and 8 % in the first season and 34, 20, 15, and 5 % in the second season when plants were subjected to water stress at severe case, vegetative, flowering and grain filling stages, respectively. The reduction in number of spikes / $m^2$, number of grains / spike and the lower seed index and decreasing the duration and rate of grain filling under high soil moisture stress may have resulted in the reduced grain yield per ha. These results are similar to those reported by McMaster *et al* (1994) and Kandil *et al* (2001).

Increasing N rates from zero up to 250 kg N /ha led to remarkable significant increase in grain yield (t / ha) in both seasons (Table 8). The yield increases due to increase in N rates from zero through 83, 166 and 250 kg / ha was reached 87.2, 133.5 and 155.5 % in the first season and 97.6, 133.2 and 151.0 % in the second season, respectively. These results are in an agreement with those stated by Nasr-Alla (2000) and El-Ganbeehy (2001).

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# تقييم صنفى قمح تحت مستويات مختلفة من الإجهاد الرطوبى والتسميد الآزوتي

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**أقيمت تجربتان حقليتان بمزرعة كلية الزراعة-سابا باشا-جامعة الإسكندرية خلال موسمى ٩٩/٢٠٠٠، ٢٠٠٠/٢٠٠١ لدراسة تأثير الإجهاد المائى بمنع الرى عند المراحل المختلفة من عمر نبات القمح صنف (سخا ٦٩، ساحل ١) عند طور النمو الخضرى، الإزهار ، تكوين الحبة وعند الأطوار الثلاثة مجتمعة (زراعة مطرية) مع استخدام أربعة مستويات للتسميد النيتروجينى (صفر، ٨٣٦، ١٦٦، ٢٥٠) كجم نيتروجين /هكتار على الصفات الفسيولوجية وناتج المحصول ومكوناته. تضمنت كل تجربة ١٢٠ قطعة تجريبية تحت شقية عبارة عن التوافيق بين خمس معاملات للإجهاد الرطوبى واربعة مستويات تسميد نيتروجينى وصنفان من القمح فى ثلاث مكررات حيث تم توزيعها فى تصميم قطع منشقة مرتين حيث تم توزيع معاملات الإجهاد الرطوبى عشوائيا فى القطع الرئيسية، وتوزيع مستويات التسميد النيتروجينى فى القطع الشقية وتوزيع الأصناف فى القطع تحت الشقية.**

ويمكن تلخيص أهم النتائج التى حصلنا عليها كالآتي:

أدى تعرض نباتات القمح للإجهاد الرطوبى خلال المراحل المختلفة الى نقص معنوى فى الصفات الفسيولوجية مثل (دليل مساحة الورقة، معدل نمو المحصول، معدل النمو النسبى ومعدل صافى التمثيل ومحتوى الأوراق من الكلوروفيل) ومحصول الحبوب ومكونات المحصول وعدد السنابل/م٢ ،عدد الحبوب فى السنبلة ووزن الألف حبة.

بينما أدى زيادة معدل التسميد النيتروجينى من صفر الى ٢٥٠ كجم ن/هكتار الى زيادة معنوية واضحة فى الصفات الفسيولوجية والمحصول ومكونات المحصول وذلك فى كلا الموسمين. وتفوق الصنف سخا ٦٩ على الصنف ساحل ١ فى محصول الحبوب طن/هكتار فى كلا الموسمين.