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# Effect of Putrescine Foliar Application on Wheat Genotypes (*Triticum aestivum* L.) under Water Stress Conditions

**Marwa MR. M. Ahmed[1]* and Mervat Sh. Sadak[2]**

[1]Botany Department, Faculty of Science, Assiut University, New Valley Branch, Egypt
[2]Botany Department, National Research Centre, 33 El-Tahrir St., Dokki, 12622 Giza, Egypt

**Abstract :** Polyamines are essential compounds and are important in cell survival. It has key roles in abiotic stress protection. The present study has been carried out to give better understanding about the effect of exogenous application of putrescine on two drought stressed wheat (Triticum aestivum L.) genotypes at the fruiting stage. The experiment consisted of four water stress conditions (90%, 70%, 50% and 30%) FC. One group of each concentration was sprayed with 0.2 mM putrescine. The wheat genotypes varied greatly in their drought tolerance and also towards putrescine treatment. Data indicated that Sakha61 tolerated drought stress up to 30% FC while Sakha69 was a drought sensitive genotype because it gave no productivity at the severe drought stress conditions. Foliar application of 0.2 mM putrescine resulted in some contradictory conclusions of a biphasic effect (stimulatory and inhibitory) under the different drought stress levels. The best stimulation in all the studied growth, yield and physiological parameters was recorded at 50% FC among both wheat genotypes studied.
**Key wards :** Drought, Putrescine, Polyamines, Wheat.

## Introduction

Water deficit affects seriously the different aspects of plant biological processes such as growth, physiology, biochemistry and crop productivity [1]. Water stress caused delay in plant growth and this may be due to disturbance of photosystem II[2].

Wheat (*Triticum aestivum* L.) considered as one of highly economic crops of nutritional value and widely grown in the world. Wheat commonly contains large amounts of carbohydrates, proteins, minerals and vitamins. In Egypt, Wheat has a great importance in order to meet the increasing local consumption.

Polyamines are found in the different plant cells. They have an essential role in the different cellular processes[3]. In addition, they retard cellular deterioration[4]. Putrescine, spermine and spermidine are the common polyamines found in the higher plants. Polyamines are commonly related to stresses responses and it gave positive roles in drought tolerance[5]. In addition, Polyamines play an essential role in keeping integrity of membrane and nucleic acid under the different stresses and a potential role which prevent degradation of chlorophyll in leaf discs of different higher plants[6]. Adding putrescine to bean plants creates significant increase in growth of fresh and dry weights[7] and this is in agreement with [8] who detected increament in grain yield of wheat plant by putrescine. Treating *Pisum sativum* plants with putrescine resulted in marked increase in the soluble protein[9]. Also, [10] found marked increase in K and Ca accumulations in wheat root and shoot of by polyamine application.

Because of the stimulatory effect of polyamines on yield, polyamines considered mainly as a new class of growth substances and are common for their anti-deterioration effects due to their antioxidant properties and membrane stabilization ability[11].

On the other hand, contradictory reports proved that rice seeds pretreatment with putrescine caused unincrease in putrescine content in shoots, but didn't alleviate the inhibition of salinity on seedling growth[12]. Plants with high polyamines concentration due to exogenous apply or endogenous production can tolerate short term exposure to many stress factors, only little studies on the survival and yield in these plants under prolonged stress conditions have been detected[13].

The present work aimed to follow the effect of foliar application of 0.2 mM putrescine on growth and yield components of two water-stressed wheat genotypes at the fruiting stage. The growth criteria, photosynthetic pigments, fresh and dry weight, soluble and total protein contents, total amino acids content and some minerals of the different organs were studied.

## Materials and Methods:

Grains of two wheat genotypes (*Triticum aestivum* L.) Sakha61 and Sakha69 were obtained from seeds station breeding program of Beni-suef, Egypt. Four grains were sown in large pots (5 kg clay soil/pot). Pots were well-irrigated with the total field capacity to enable the beginning of seedling emergence. After the first irrigation, pots watered with four different levels of soil moisture content (90, 70, 50 and 30% field capacity FC). Grains left to grow for 130 days. Another second group included the same four drought stress levels treated with foliar spray with 10 ml/plant 0.2 mM of putrescine which applied two times at the age of 40 days and 60 days. After harvesting, plant height and fresh weight of the different organs were estimated. Thereafter, it dried in an aerated oven (Hotbox Oven, Gallenkamp, England) at 80°C. Leaf area measured by determining leaf length and maximum leaf width as follows; Leaf area = k (leaf length x leaf maximum width) $Cm^2$/plant. The coefficient k was given a value of 0.75 for wheat by[14].

The different Photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids = total pigments) were detected by[15] as mg/g DW. Soluble and total proteins were measured regarding to[16]. Total proteins extracted by[17]. Total free amino acids were calculated according to[18] as mg/g DW. Some minerals are determined at the soluble extract as mg/g dry matter. $K^+$ content was estimated by[19] using Carl Zeiss flame photometer. $Ca^{++}$ and $Mg^{++}$ were estimated using versene-titration method[20].

Statistical analysis of this study was done using SPSS. Differentiations between means among different treatments were estimated by Duncan's test at 5%[21].

## Results:

Data (in table 1) indicated that shoot length and leaf area of both tested genotypes decreased by increasing drought stress used in the soil. The maximum reduction recorded at the severe drought stress level used (30% FC). Percentage of reduction at severe drought stress level used in leaf area was 12% and 51% in Sakha61 and Sakha69 respectively, while shoot length reduction recorded as about 28% and 40% in Sakha61 and Sakha69 respectively. Plants Sprayed with putrescine showed marked variations in their response towards the drought stress. Lower drought stress levels (90% & 70% FC) showed mostly no obvious changes by putrescine treatment in Sakha61 genotype. In Sakha69 there was an inhibitory effect of putrescine at the lower drought levels. The best stimulation was recorded by putrescine at the 50% FC in both tested wheat genotypes.

Also, total pigments determination resulted more percent of reduction in Sakha69 than Sakha61 at the severe drought stress. In Sakha61 and Sakha69 putrescine treatment enhanced total pigmentation at the severe drought stress levels used (50% & 30%) from the control plants but inhibited it at (90% & 70% FC).

**(Table 1): Effect of drought stress and putrescine foliar application on the shoot length (cm), leaf area ($cm^2$) and total pigmentats of two wheat genotypes.**

| Treatment | Genotype | Sakha61 | | | Sakha69 | | |
|---|---|---|---|---|---|---|---|
| | % of FC | Sh.L (cm) | L.A ($cm^2$) | T.Pigments (mg/g DW) | Sh.L (cm) | L.A ($cm^2$) | T.Pigments (mg/g DW) |
| Control | 90 | $63.60^{f}$ | $89.52^{f}$ | $11.76^{e}$ | $59.75^{h}$ | $81.74^{g}$ | $7.46^{a}$ |
| | 70 | $60.80^{cd}$ | $87.68^{e}$ | $10.56^{d}$ | $53.70^{f}$ | $71.60^{f}$ | $5.61^{a}$ |
| | 50 | $56.00^{b}$ | $83..48^{c}$ | $9.28^{c}$ | $41.50^{c}$ | $57.40^{c}$ | $4.47^{a}$ |
| | 30 | $45.80^{a}$ | $79.14^{a}$ | $8.08^{b}$ | $36.30^{b}$ | $40.19^{b}$ | $3.22^{a}$ |
| (0.2 mM) Putrescine | 90 | $62.60^{e}$ | $87.38^{e}$ | $8.67^{bc}$ | $55.1^{g}$ | $69.60^{e}$ | $5.32^{a}$ |
| | 70 | $60.30^{c}$ | $85.30^{d}$ | $7.38^{a}$ | $47.6^{d}$ | $64.97^{d}$ | $4.78^{a}$ |
| | 50 | $61.50^{d}$ | $87.70^{e}$ | $10.86^{d}$ | $49.7^{e}$ | $72.10^{f}$ | $7.54^{a}$ |
| | 30 | $55.20^{b}$ | $81.46^{b}$ | $8.75b^{c}$ | $34.1^{a}$ | $38.60^{a}$ | $4.48^{a}$ |

Means with different superscripts within the same column are significantly differ ($P \leq 0.05$)

Fresh and dry matters of different parts of Sakha 61 wheat genotypes were decreased gradually by increasing the drought stress. In Sakha69 genotype both the fresh and dry matter decreased significantly by increasing drought. The more reduction was recorded at the severe water stress level (30% FC). In Sakha61, the spike dry matter reduced by about 30% while in Sakha69 the plants failed to produce spikes at the severe drought stress level. This indicates more drought tolerance for Sakha61 genotype. The best stimulation caused by putrescine was mostly at the level of 50% FC in both genotypes. Putrescine treatment caused obvious reduction in fresh and dry matter of Sakha69 at the rest of drought stress levels used except 50% FC. In Sakha61, reduction registered at lower drought stress level used while little stimulation recorded at the level of 50%, 30% FC from their corresponding control plants.

**(Table 2): Effect of drought stress and putrescine foliar application on the fresh and dry weight (g) of root, shoot and spike of Sakha61 wheat genotype.**

| Sakha 61 Treatment | % of FC | Root | | Shoot | | Spike | |
|---|---|---|---|---|---|---|---|
| | | F.wt (g) | D.wt (g) | F.wt (g) | D.wt (g) | F.wt (g) | D.wt (g) |
| Control | 90 | $4.68^{e}$ | $0.75^{e}$ | $10.32^{d}$ | $3.73^{d}$ | $2.43^{cde}$ | $0.68^{d}$ |
| | 70 | $4.32^{d}$ | $0.63^{cd}$ | $9.80^{cd}$ | $3.19^{c}$ | $2.13^{abcd}$ | $0.6^{bc}$ |
| | 50 | $3.79^{c}$ | $0.58^{bc}$ | $8.84^{bc}$ | $2.85^{bc}$ | $2.04^{abc}$ | $0.56^{b}$ |
| | 30 | $2.56^{b}$ | $0.49^{b}$ | $7.81^{ab}$ | $2.44^{ab}$ | $1.76^{a}$ | $0.476^{a}$ |
| (0.2 mM) Putrescine | 90 | $4.20^{c}$ | $0.54^{cd}$ | $6.86^{a}$ | $2.78^{bc}$ | $2.40^{bcde}$ | $0.63^{cd}$ |
| | 70 | $2.45^{c}$ | $0.34^{b}$ | $6.96^{a}$ | $2.14^{a}$ | $2.55^{de}$ | $0.69^{d}$ |
| | 50 | $4.23^{d}$ | $0.66^{d}$ | $9.14^{c}$ | $3.06^{c}$ | $2.70^{e}$ | $0.82^{e}$ |
| | 30 | $2.811^{a}$ | $0.57^{a}$ | $8.63^{ab}$ | $2.93^{c}$ | $1.95^{ab}$ | $0.56^{b}$ |

Means with different superscripts within the same column are significantly differ ($P \leq 0.05$)

**(Table 3): Effect of drought stress and putrescine foliar application on the fresh and dry weight (g) of root, shoot and spike of Sakha69 wheat genotype.**

| Sakha 69 Treatment | % of FC | Root | | Shoot | | Spike | |
|---|---|---|---|---|---|---|---|
| | | F.wt (g) | D.wt (g) | F.wt (g) | D.wt (g) | F.wt (g) | D.wt (g) |
| Control | 90 | $4.25^{c}$ | $0.66^{e}$ | $9.69^{d}$ | $3.85^{d}$ | $2.72^{c}$ | $0.65^{b}$ |
| | 70 | $3.72^{bc}$ | $0.48^{cd}$ | $8.64^{c}$ | $2.8^{c}$ | $2.16^{ab}$ | $0.444^{a}$ |
| | 50 | $2.64^{b}$ | $0.41^{bcd}$ | $6.95^{b}$ | $1.99^{b}$ | $1.87^{a}$ | $0.382^{a}$ |
| | 30 | $1.97^{a}$ | $0.364^{b}$ | $4.9^{a}$ | $1.16^{a}$ | ---- | ---- |
| (0.2 mM) Putrescine | 90 | $2.94^{bc}$ | $0.48^{bc}$ | $8.6^{c}$ | $2.71^{c}$ | ---- | ---- |
| | 70 | $2.25^{a}$ | $0.39^{a}$ | $6.51^{b}$ | $1.8^{b}$ | ---- | ---- |
| | 50 | $3.69^{bc}$ | $0.547^{de}$ | $9.52^{d}$ | $2.83^{c}$ | $2.53^{bc}$ | $0.589^{b}$ |
| | 30 | $0.93^{a}$ | $0.18^{bcd}$ | $4.3^{a}$ | $0.91^{a}$ | ---- | ---- |

Means with different superscripts within the same column are significantly differ ($P \leq 0.05$)

In Sakha61 the soluble protein increased by elevating the drought stress level at the different tested plant organs. A little retardation was detected at the higher drought stress level. In Sakha69 the soluble and total proteins markedly decreased by elevating the drought stress level in the soil. Putrescine treatment generally stimulated the soluble protein content among the two tested wheat genotypes by imposing drought stress over the control plants. Putrescine also stimulated total protein content by elevating the imposed drought level in the soil in the different organs of Sakha61 genotype and in root and spike of Sakha69 plants. In Sakha69 shoot, total protein decreased at the lower drought stress levels (90% & 70% FC) but little increase recorded at the higher drought stress levels (50% & 30% F.C) when compared with their corresponding unsprayed plants.

**(Table 4): Effect of drought stress and putrescine foliar application on the soluble and total protein content (mg/g dry weight) of root, shoot and spike of the two wheat genotypes.**

| Protein fraction | Genotype Treatment | % of FC | Sakha61 | | | Sakha69 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Root | Shoot | Spike | Root | Shoot | Spike |
| Soluble protein | Control | 90 | 64.05$^{b}$ | 58.43$^{b}$ | 112.78$^{b}$ | 57.70$^{d}$ | 55.04$^{b}$ | 85.62$^{c}$ |
| | | 70 | 79.90$^{c}$ | 63.72$^{c}$ | 107.19$^{a}$ | 59.40$^{e}$ | 65.80$^{d}$ | 76.32$^{b}$ |
| | | 50 | 100.45$^{f}$ | 71.36$^{d}$ | 127.31$^{d}$ | 47.40$^{b}$ | 54.80$^{b}$ | 53.42$^{a}$ |
| | | 30 | 98.90$^{e}$ | 87.38$^{e}$ | 121.43$^{c}$ | 40.31$^{a}$ | 36.90$^{a}$ | ---- |
| | (0.2 mM) Putrescine | 90 | 61.10$^{a}$ | 57.30$^{a}$ | 114.05$^{b}$ | 66.9$^{g}$ | 57.60$^{c}$ | ---- |
| | | 70 | 86.95$^{d}$ | 64.22$^{c}$ | 133.13$^{e}$ | 61.10$^{f}$ | 68.95$^{e}$ | ---- |
| | | 50 | 101.70$^{f}$ | 87.80$^{e}$ | 142.60$^{f}$ | 66.40$^{g}$ | 74.50$^{f}$ | 121.00$^{d}$ |
| | | 30 | 86.62$^{d}$ | 93.63$^{f}$ | 143.24$^{f}$ | 49.70$^{c}$ | 57.20$^{c}$ | ----- |
| Total protein | Control | 90 | 201.90$^{a}$ | 214.60$^{b}$ | 187.75$^{b}$ | 217.50$^{g}$ | 255.00$^{a}$ | 176.45$^{d}$ |
| | | 70 | 221.30$^{cd}$ | 233.25$^{d}$ | 204.60$^{e}$ | 201.92$^{d}$ | 216.00$^{a}$ | 157.25$^{b}$ |
| | | 50 | 214.41$^{b}$ | 213.12$^{b}$ | 201.50$^{d}$ | 192.00$^{c}$ | 183.45$^{a}$ | 151.50$^{a}$ |
| | | 30 | 203.10$^{a}$ | 208.70$^{a}$ | 183.10$^{a}$ | 177.50$^{a}$ | 173.47$^{a}$ | ----- |
| | (0.2 mM) Putrescine . | 90 | 223.50$^{d}$ | 218.36$^{c}$ | 195.91$^{c}$ | 236.25$^{h}$ | 245.87$^{a}$ | ----- |
| | | 70 | 218.93$^{c}$ | 235.14$^{d}$ | 210.30$^{f}$ | 214.00$^{f}$ | 209.50$^{a}$ | ----- |
| | | 50 | 251.34$^{f}$ | 242.36$^{e}$ | 235.40$^{g}$ | 205.65$^{e}$ | 221.00$^{a}$ | 160.38$^{c}$ |
| | | 30 | 237.53$^{e}$ | 241.30$^{e}$ | 204.70$^{e}$ | 189.25$^{b}$ | 181.40$^{a}$ | ---- |

Means with different superscripts within the same column are significantly differ ($P \leq 0.05$)

Total free amino acids increased markedly in both tested wheat genotypes among the three tested plant organs by elevating the drought stress in the soil. The higher stimulation recorded at 70% FC in Sakha61 and 30% FC of Sakha69 plants. Putrescine treatment in most cases stimulated the total amino acids content of Sakha61. Stimulatory effect in Sakha69 genotype was recorded only at 50% FC.

**(Table 5): Effect of drought stress and putrescine foliar application on the total free amino acids content (mg/g DW) of root, shoot and spike of the two wheat genotypes.**

| Genotype Treatment | % of FC | Sakha61 | | | Sakha69 | | |
|---|---|---|---|---|---|---|---|
| | | Root | Shoot | Spike | Root | Shoot | Spike |
| Control | 90 | 27.30$^{a}$ | 10.07$^{a}$ | 34.80$^{e}$ | 17.70$^{b}$ | 18.63$^{b}$ | 29.73$^{b}$ |
| | 70 | 33.30$^{d}$ | 20.10$^{d}$ | 40.40$^{g}$ | 29.04$^{e}$ | 24.92$^{c}$ | 32.80$^{c}$ |
| | 50 | 30.00$^{b}$ | 21.45$^{e}$ | 29.70$^{b}$ | 30.40$^{f}$ | 30.61$^{e}$ | 33.20$^{c}$ |
| | 30 | 31.50$^{c}$ | 12.57$^{b}$ | 25.60$^{a}$ | 33.23$^{g}$ | 25.52$^{c}$ | ---- |
| (0.2 mM) Putrescine | 90 | 29.98$^{b}$ | 12.07$^{b}$ | 33.46$^{d}$ | 16.52$^{a}$ | 16.37$^{a}$ | ----- |
| | 70 | 31.50$^{c}$ | 23.30$^{f}$ | 37.23$^{f}$ | 28.20$^{d}$ | 27.67$^{d}$ | ---- |
| | 50 | 33.60$^{d}$ | 24.60$^{g}$ | 34.40$^{e}$ | 33.58$^{g}$ | 33.45$^{f}$ | 25.26$^{a}$ |
| | 30 | 37.29$^{e}$ | 15.66$^{c}$ | 32.26$^{c}$ | 25.56$^{c}$ | 27.40$^{d}$ | ------ |

Means with different superscripts within the same column are significantly differ ($P \leq 0.05$)

$K^+$ content increased markedly in roots and shoots but decreased in spike of Sakha61 by elevating drought stress. Putrescine treatment generally increased the $K^+$ content by increasing the water stress from their corresponding levels. Little reduction recorded only at roots of 30% FC and spike of 90% FC.

In Sakha69, $K^+$ content increased in roots up to 50% FC then, it decreased at 30% FC. $K^+$ content decreased markedly in shoot and spike by increasing drought stress in soil. Putrescine treatment gave best stimulation of $K^+$ content at 50% F.C roots, shoots and spikes. At the lower drought stress levels (90%, 70% FC), there was a reduction in $K^+$ content.

$Ca^{++}$ and $Mg^{++}$ content of root, shoot and spike of Sakha61 increased markedly by elevating the drought stress but little reduction was recorded only at 30% FC especially in spike. In the different organs of Sakha69 Ca and Mg content decreased markedly by increasing drought stress. Foliar application of putrescine affected the two genotypes differently. In Sakha61, putrescine treatment induced marked reduction in $Ca^{++}$ content of roots by increasing the drought level used from their corresponding control. $Ca^{++}$ content of shoot and spike increased markedly by drought stress except in 30% FC shoots where a little reduction recorded.

**(Table 6): Effect of drought stress and putrescine foliar application on some minerals contents (mg/g DW) of root, shoot and spike of Sakha61 wheat genotype.**

| **Genotype** | | **Sakha61** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Minerals** | | **$K^+$** | | | **$Ca^{++}$** | | | **$Mg^{++}$** | | |
| **Treatment** | **% of FC** | **Root** | **Shoot** | **Spike** | **Root** | **Shoot** | **Spike** | **Root** | **Shoot** | **Spike** |
| Control | 90 | $2.43^{a}$ | $15.39^{c}$ | $4.77^{b}$ | $8.75^{de}$ | $13.91^{a}$ | $23.65^{c}$ | $1.72^{a}$ | $6.13^{b}$ | $16.25^{b}$ |
| | 70 | $3.46^{b}$ | $15.58^{c}$ | $3.62^{a}$ | $8.90^{de}$ | $19.50^{c}$ | $26.25^{e}$ | $1.80^{ab}$ | $6.89^{c}$ | $18.31^{e}$ |
| | 50 | $3.9^{b}$ | $18.9^{e}$ | $3.66^{a}$ | $10.43^{f}$ | $16.50^{b}$ | $28.50^{g}$ | $1.86^{ab}$ | $7.10^{d}$ | $16.50^{bc}$ |
| | 30 | $4.25^{d}$ | $18.6^{a}$ | $3.12^{d}$ | $10.9^{b}$ | $16.35^{b}$ | $19.75^{a}$ | $1.80^{ab}$ | $6.03^{b}$ | $15.25^{a}$ |
| (0.2 mM) Purescine | 90 | $2.46^{c}$ | $17.62^{b}$ | $4.47^{c}$ | $7.50^{a}$ | $15.75^{b}$ | $24.72^{d}$ | $1.90^{ab}$ | $7.20^{d}$ | $16.75^{cd}$ |
| | 70 | $3.86^{b}$ | $16.75^{d}$ | $4.10^{ab}$ | $6.80^{c}$ | $20.63^{d}$ | $27.54^{f}$ | $2.04^{bc}$ | $6.90^{c}$ | $17.90^{e}$ |
| | 50 | $3.99^{b}$ | $20.534^{f}$ | $4.60^{b}$ | $9.00^{e}$ | $22.10^{d}$ | $31.50^{h}$ | $1.90^{ab}$ | $8.10^{e}$ | $17.10^{d}$ |
| | 30 | $3.719^{b}$ | $20.12^{f}$ | $3.641^{a}$ | $8.50^{d}$ | $14.50^{a}$ | $22.48^{b}$ | $2.17^{c}$ | $5.40^{a}$ | $15.50^{a}$ |

Means with different superscripts within the same column are significantly differ ($P \leq 0.05$)

**(Table 7): Effect of drought stree and putrescine foliar application on some minerals contents (mg/g DW) of root, shoot and spike of Sakha69 wheat genotype.**

| **Genotype** | | **Sakha69** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Minerals** | | **$K^+$** | | | **$Ca^{++}$** | | | **$Mg^{++}$** | | |
| **Treatment** | **% of FC** | **Root** | **Shoot** | **Spike** | **Root** | **Shoot** | **Spike** | **Root** | **Shoot** | **Spike** |
| Control | 90 | $2.35^{a}$ | $18.79^{c}$ | $3.60^{b}$ | $6.00^{e}$ | $9.60^{f}$ | $15.00^{d}$ | $3.60^{c}$ | $4.36^{c}$ | $4.85^{d}$ |
| | 70 | $2.42^{a}$ | $16.563^{b}$ | $3.41a^{b}$ | $5.60^{d}$ | $6.50^{c}$ | $12.27^{b}$ | $1.92^{a}$ | $3.50^{b}$ | $3.95^{b}$ |
| | 50 | $3.11^{c}$ | $16.31^{b}$ | $3.07^{a}$ | $4.50^{c}$ | $4.30^{b}$ | $9.25^{a}$ | $1.80^{a}$ | $2.84^{a}$ | $2.65^{a}$ |
| | 30 | $3.92^{e}$ | $14.83^{a}$ | --- | $3.25^{a}$ | $3.25^{a}$ | ---- | $1.73^{a}$ | $2.60^{a}$ | --- |
| (0.2 mM) Purescine | 90 | $2.78^{b}$ | $16.77^{b}$ | --- | $7.20^{f}$ | $10.50^{g}$ | ---- | $4.32^{d}$ | $4.50^{c}$ | --- |
| | 70 | $2.40^{a}$ | $16.34^{b}$ | --- | $7.50^{f}$ | $7.25^{d}$ | ------ | $2.80^{b}$ | $5.85^{d}$ | --- |
| | 50 | $3.48^{d}$ | $18.58^{c}$ | $4.984^{c}$ | $4.60^{c}$ | $7.75^{e}$ | $13.75^{c}$ | $1.80^{a}$ | $4.50^{c}$ | $4.43^{c}$ |
| | 30 | $3.35^{d}$ | $14.854^{a}$ | --- | $4.10^{b}$ | $4.50^{b}$ | ---- | $1.90^{a}$ | $2.70^{a}$ | --- |

Means with different superscripts within the same column are significantly differ ($P \leq 0.05$)

$Mg^{++}$ content increased markedly by increasing drought stress levels except a little reduction recorded at 30% FC shoots. Putrescine treatment increased both $Ca^{++}$ and $Mg^{++}$ content by increasing drought stress level from their corresponding drought stress levels in the different tested organs of Sakha69 wheat genotype.

## Discussion:

Abiotic stress such as water deficiency has threatened crop productivity seriously. In the coming climatic change drought stress is predicted to be increased. Many studies are needed to cope with the coming environmental climatic challenges in order to enable crop protection and survival. Polyamines are a group of natural compounds found mostly in the living organisms including plants[22]. Putrescine as one of the polyamines has been involved in the different growth and developmental processes in the plant[23]. Polyamines are essential in modulating the plant responses under different abiotic stresses[24]. There are doubts about recognizing Polyamines as one of the plant growth regulators[25]. The interactive effect of drought and putrescine application on wheat growth, productivity, minerals and different metabolic compounds distribution in root, shoot and spike was studied. Water stress commonly decreased the shoot length, blade leaf area, fresh and dry matter of the different organs of the studied wheat genotypes as compared to the control plants. Photosynthetic pigments were parallel to the previous growth parameters studied. The result showed a reduction in the total pigments content under water stress by increasing drought stress level. Chlorophyll content reduced because the drought conditions delay the photosynthesis and transpiration in wheat[26]. The marked reduction in growth parameters may be due to loss of turgidity which affects the rate of cell size and expansion generally, growth reduction is common response to water stress. Growth parameters are important in representing the wheat drought stress tolerance[27].

Marked variations in yield were accompanied to drought stress. Crops that grown under control conditions (90% FC) stress recorded significantly higher yield (spike dry weight). The highest reduction in the yield was shown under severe drought conditions at 30% FC. The two wheat genotypes differed in the percent of reduction so, it can be concluded that Sakha61 is a drought tolerant wheat genotype while Sakha69 is a drought sensitive genotype. The percent of reduction in dry matter yield of spike of Sakha61 was 30% at the severe drought stress level while Sakha69 plants failed to produce crop yield at the same drought stress level. In agreement with[28], there was a significant reduction in fresh and dry matter of root, shoot and spike of wheat genotypes accompanying the increase in drought stress level that attributed to the effect of water in stimulating the photosynthetic enzymes and growth hormones. The growth reducing patterns of water stress may be due to the decrease in photosynthesis and photosynthetic pigments (Chl a, Chl b, and carotenoids).

Putrescine foliar application resulted in wide variations among the two tested wheat genotypes under the different drought levels used. Best stimulation caused by putrescine was recorded at 50% FC at the two tested wheat plants. Better stimulation was higher in the tolerant genotype Sakha61 than Sakha69 wheat genotype. Polyamines can protect the different activities of the whole electron transport chain, photosystem I and Π , and absorbed excitation energy distribution in the favor of system I[29]. Also,[30] found that spraying of putrescine in drought stressed wheat plants, markedly increased photosynthesis, increased contents of protein and total amino acids, retarded membrane damage and significantly increased yield as compared with control plants.

Many studies improve that putrescine decreases the sensitivity of plants towards water stress. In this study, foliar application of polyamine such as putrescine could reduce the effects of drought stress as detected at 50% FC at both tested wheat genotypes, while the reduction caused by putrescine application at the lower drought stress conditions among the two studied genotypes are agreed with[31] who reported that polyamines treatment of barley leaf discs declined the activity of photosystem I and II in the chloroplast resulting in a destruction of their envelope. This agreed with[32] who have shown an inhibitory influence of polyamine on photosynthesis in rice. Increase in yield attributes at 50% FC at the two tested wheat genotypes over the control plants could be because of the role of putrescine in stimulation of many processes inside the plant cell such as respiration and photosynthesis and increased the different photosynthetic products of the wheat plants under this drought stress level. Consequently, it increased the rate of dry matter translocation leading to increase in spike dry matter. Therefore, putrescine found to be of bio-regulatory effects, chiefly through mobilization of dry matter and translocation of photosynthates resulting in an improved yield formation while some other studies detected that application of putrescine to leaves or roots did not improve shoots or roots dry matter under control or saline conditions[33].

This study proved that water stress commonly caused marked reduction in total proteins and caused progressive accumulation of compatible solutes in wheat plants. Commonly, the drought stress increased the accumulation of soluble proteins, total free amino acids and some minerals (K, Ca and Mg) but the percent of reduction varied markedly among the two wheat genotypes due to their variation in drought tolerance. These soluble solutes protect cellular components and are considered as osmoprotectants and compatible solutes. Water stress decreased total protein but increased the soluble content. This change may be related to inhibition of protein synthesis or the increase of protease activity. Putrescine treatment resulted in marked enhancement in the soluble and total proteins among the different plant parts in the two studied wheat genotypes under water stress as compared to the control untreated plants.

Drought stress caused significant increase in the total free amino acids of both tested wheat genotypes. The variation in the accumulations of the total free amino acids among the two wheat genotypes different organs is related to the variation in their drought tolerance. The increase in the total amino acids under drought stress could be mainly regarding to hydrolysis of proteins this agreed with[34] who detected similar conclusion on studying *Phaseolus vulgaris* and *Sesbania aculeate.* Accumulation of amino acids under the putrescine treatment especially under the severe drought conditions has been recorded. The increase in amino acids might result from amino acid production and/or from enhanced stress induced protein degradation. While the overall accumulation of amino acids upon stress might indicate cell damage in some cases as in 30% FC in the sensitive genotype Sakha69, it have a beneficial effect during stress acclimation in the tolerant Sakha61 wheat genotype.

The increasing trend of $K^+$ accumulation in roots and shoots with little reduction in spike of Sakha61 reflecting good absorption and translocation and is related to the drought tolerance of this genotype. Contradictory in Sakha69 genotype, $K^+$ content showed little increase in roots by increasing drought stress but marked reduction in shoot and spike and this is related positively to the sensitivity of this genotype towards drought stress. $Ca^{++}$ and $Mg^{++}$ content increased markedly in Sakha61 by increasing drought stress among the different organs tested while it decreased markedly in Sakha69. This is could be strongly related with the variation in the drought tolerance among the two wheat genotypes. It is now clear that the $K^+$, $Ca^{++}$ and $Mg^{++}$ content and distribution has a positive role in drawing the drought tolerance of wheat genotypes unless in this study and it can be considered as the limiting factor of growth in wheat plants.

Putrescine application generally increased $K^+$ content among the different organs at the different drought stress levels in Sakha61 wheat genotype. The increase in $K^+$ content under control condition (90% FC) did not improve plant growth nor give better crop yield (spike weight) than the control untreated plants. In Sakha69 $K^+$ content reduced at low water stress but increased at the highest drought stress conditions (50% & 30%) FC. The increase in roots and shoots $K^+$ content didn't benefit to this genotype to give any crop (spike) at 30% FC, it didn't improve the tolerance of this genotype at the severe drought level. Foliar application of 0.2 mM putrescine enhanced also the accumulation of Ca and Mg under different water stress levels used and among the different plant organs except in Sakha61 roots, putrescine treatment caused reduction in Ca content and this might indicate better translocation towards the aerial parts. The increase in Ca and Mg content under control conditions (90% FC) sprayed with putrescine in the two tested wheat genotypes did not improve plant growth or crop yield than the control untreated plants.

Wide discussion has been resulted about whether high polyamines content may save plants versus abiotic stress because of their ability in dealing with the oxidative radicals, or they may cause plant damage due to hydrogen peroxide created by their catabolism. The observation of putrescine response in plants under different drought stress levels is consistent with the possibility of the dual effects caused by putresine (being protectors from as well as perpetrators of cellular stress damage), these data is agreed with[13].

It can be concluded that spray of 0.2 mM putrescine gave a positive ameliorative effect mostly at 50% FC where it stimulated the different growth parameters, photosynthetic pigments, crop yield, protein conent, total free amino acids content and also the concentration and translocation of some minerals (K, Ca and Mg) over the corresponding control plants. Data of putrescine treatment in this study was to some extent surprising, it indicated a complex relationship between foliar application of putrescine and water stress in wheat plants. Although putrescine was well known previously as a growth stimulator, in this study it proved to have a biphasic effect under the different drought stress levels among the two wheat genotypes as follows: In Sakha61, the most drought tolerant wheat genotype putrescine treatment gave two opposite responses at the severe (50% & 30%) and low (90% & 70%) drought stress conditions. At low drought stress conditions putrescine treatment caused

retardation at all the tested growth and biochemical parameters while at the high drought stress levels, putrescine exhibited positive stimulatory effect among the different studied physiological parameters. In Sakha69, the most drought sensitive wheat genotype also a dual effect of putrescine was detected. While a positive ameliorative effect was detected only at 50% FC, other drought stress levels produced no crop yield by putrescine treatment.

The variation in the responses of the two drought stressed wheat genotypes might be mainly regarding to the degree of tolerance or sensitivity of each genotype towards drought stress. Although many literatures go ahead using polyamines as a growth hormone, it can be detected here that putrescine has dual influence on drought tolerance of the two studied wheat genotypes at the fruiting stage. This effect may be strongly related to the severity of the water stress imposed, type of plant and the genetic structure of the different genotypes.

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