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**Abstract**
This study carried out in a greenhouse experiment at Makah Al Mukaramah City, Kingdom of Saudi Arabia. The wheat grains pure strain was obtained from Agricultural Research Station of King Saud University Kingdom of Saudi Arabia. Presoaked wheat grains (*Triticum aestivum*, L. cv. Pavon 76 & cv. Yecora Rojo) in freshly prepared salicylic acid (0.5 mM SA) or distilled water (control) for 12 h at natural environmental conditions, to reduce the effect of water stress. Generally, the wheat grains germination occurred after 4-5 days for cv. Pavon 76 (-SA) and (+ SA) respectively, whereas, the wheat grain germination occurred after 5-7 days for cv.Yecora Rojo (- SA) and (+ SA) respectively. While, the germination rate (%) were faster after soaking the wheat grains for both cultivars in salicylic acid (+SA) compared with control (soaked in distilled water). Water field capacity treatments 60% and 40% (dry and very dry respectively) caused a reduction in most growth parameters (shoot and root length (cm/plant), leaf area (cm²) and number per plant & shoot and root fresh and dry weights (g/plant organ) compared with control, particularly at very dry level (40%) more reduced but loss of water tended to increase the yield production. At 100% water field capacity (wet treatment) tended to increase the growth parameters but reduce the yield production. In the meantime, salicylic acid had reduced the effect water field capacity stress on germination, growth parameters and yield production whereas increased the more than in the absent of salicylic acid.

**Keywords:** *Triticum aestivum*; salicylic acid; water field capacity treatments; germination, growth parameters; yield production.

**Introduction**
Water deficit is one of the main problems affecting food production in the world, reducing crop productivity it occurs in plants when the water supply is in sufficient to maintain growth, photosynthesis and transpiration (Moura et al., 2009). Drought adversely affects plant growth and development, seed germination (Dash and Panda, 2001; Almaghrabi, 2012), seedling growth (Ashraf et al., 2002), DNA, RNA, and protein synthesis (Anuradha and Rao, 2001) and mitosis (Tabur and Demir, 2010).

Wheat (*Triticum aestivum* L.) is one of the main cereal crops in the world together with maize and rice (Wang et al., 2009). It can be cultivated in a wide range of agricultural environments; water availability is the most limiting factor for wheat production in the arid and semi-arid Mediterranean-type environments (Kashiani et al., 2011).Gomez *et al.* (1993) observed greater economic yield of wheat genotypes grown under water stress, when treated with SA. Plants respond to stress by the synthesis of signaling molecules. These activate a range of signal transduction pathways. Several such signaling molecules have been identified in plants as calcium, jasmonic, ethylene and ethylene and SA.

The role of SA as a defense signal has been well established in plants (Ganesan, and Thomas, 2001; Klessig, and Malamy, 1994). SA has qualified as a plant hormone due to its physiological and biochemical roles in plants (Raskin, 1992a & b). SA has been suggested as signal transducer or messenger under stress conditions (Klessig, and Malamy, 1994).Noreen et al. (2009) reported that salicylic acid (SA) induces the growth in sunflower lines. Salicylic acid (SA) stimulates the antioxidant capacity, so that the leaf peroxidase activity has increased. Positive correlation between leaf peroxidase and super oxide dismutase activities were observed in sunflower lines with root fresh weight and CO₂ exchange system. Salicylic acid (SA) increases abscissic acid (ABA) content under stress and maintains the reduction of harmful effects of stress on the plant (Ianovici, 2011) and causes plants to re-grow (Sakhabutdinova et al., 2000).Plant growth regulators can improve the physiological efficiency including photosynthetic ability and thereby helping in effective flower
formation, fruit and seed development and ultimately enhance productivity of the crops (Solamani et al., 2001). Foliar feeding of plants can effectively supplement soil fertilization. It has been found that element foliar application is more influential compared to soil application (Kazemi, 2013).

At the present, the growth of wheat has been seriously influenced by drought in many regions. The present study was conducted to assess whether exogenous application of SA could ameliorate the adverse effects of water stress on wheat plants. The aim of this study is the interaction effects of drought stress with SA on germination, growth parameters and yield production of wheat cultivars (Triticum aestivum L. cv, Pavon 76 & cv. Yecora Rojo). Wheat is one of the most important crops in the world.

**Materials and Methods**

*Wheat Plant and Culture Techniques*

*Plant Materials:* The experimental plant used in this investigation was wheat (Triticum aestivum, L.) plants, two different types can be distinguished, (1) - cv. Pavon 76 resistance to drought, and (2) - cv. Yecora Rojo Sensitive to drought stress, pure strain of grains was obtained from Agricultural Research Station of King Saud University Kingdom of Saudi Arabia.

*Nutrient Solutions:* The base nutrient solution used was similar to that applied by Hoagland and Arnon (1950)

*Water Treatments (Irrigation System):* After 12 a day, thinning was carried out 5 uniform plants per pot for experimentation. The 144 pots used were divided into 2 (72 Pots) groups (two cultivars) that were subjected to (4) different water treatments on the 10th days as indicated in the following scheme: (100%; 80% @; 60%; 40%) in addition to Hoagland solution (nutrient solution) by using a hand spray, irrigated plants. The normal water holding capacity of the mixture of soil used was 80% @ to maintain the field capacity characteristic of each of the 3 water treatment as indicated in the scheme as in Table (1), watering was carried out every day (100%), every two days 80% @, every three days (60%) and every fourth day (40%). Watering was always made when the field capacities were lowered to 100%, 80% (C), 60%, 40% for wet, normal (control), dry and very dry respectively was found to differ with the progress in plant growth and with the climatic conditions during the duration of the experiment.

*The Soil Used* for cultivated wheat plant was the ratio between the sand and peatmoss (1:2 – v: v), added in each pot (diameter 16 cm and depth of 16 cm), by the same ratio of the soil of the volume.

*Test of Grains Viability and Germination in the absent and present Application of Salicylic Acid (SA) on Wheat Grains Before Germination:* Viability and germinated of wheat (Triticum aestivum, L.) grains for two cultivars, (cv. Pavon 76 Resistance to Drought Stress and cv. Yecora Rojo Sensitive to Drought Stress) by different characteristics used for cultivation in the greenhouses at Makah Al Mukaramah City, Kingdom of Saudi Arabia. The wheat grains from different cultivars germination at 20 - 24°C in Petri dishes with a diameter (10 cm) on filter papers Whatman No.1, and moistened with distilled water. Selected of the grains intact, Homogeneous in size and free from wrinkles to plant wheat cultivar (cv. Pavon 76 Resistance to Drought Stress and cv. Yecora Rojo Sensitive to Drought Stress). Then soaked the grains for 12 hours in the dark using the following solutions where seeds were divided into two groups as follows: First group (1): Grains soaked in distilled water. Second group (2); Grains soaked in a solution of salicylic acid (SA – 0.5 mM) concentration. Germination (%): Five seedlings from each treatment were taken to measure seed germination. Percentage germination was measured using the following formula. Calculated the germinated grains percentage for every cultivar of wheat plant by the following equation:

\[
\text{Total Germinated Grains} (%) = \frac{\text{Total Number of Germinated Grains}}{\text{Total Number of Grains (45)}} \times 100
\]

*Transplanting of Wheat Seedling:* The seedling plant transplanted after germinated by 14 days in trays of cork (39 cm × 67 cm), which containing 218 tray diameter eye (3cm and depth 6.5 cm). The tray eyes containing an equal amount of peat-moss only mixture thoroughly with water so distributed one grain in each eye tray and left the grain to grow under greenhouse conditions at temperature of 18°C ±1°C (night)/ 22°C ± 2°C (day) and relative humidity varied between 60-70%. The wheat grains watering using distilled water until the true leaf appearance then transferred to another pots (diameter 16 cm and depth of 16 cm) which containing the sandy soil washed by diluted hydrochloric acid (1N HCl) and washed thoroughly with distilled water more five times. Used the same pots, and

**Table 1. The Time Table for Water Irrigation (W.F.C. %) 100%, 80%, 60%, 40% for wet, normal (control), dry and very dry respectively per Day.**

<table>
<thead>
<tr>
<th>Water Treatments (W.F.C. %)</th>
<th>Time for Irrigation (Day)</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>Every Day</td>
<td>Wet</td>
</tr>
<tr>
<td>80% @</td>
<td>Every two Days</td>
<td>Normal (Control)</td>
</tr>
<tr>
<td>60%</td>
<td>Every Three Days</td>
<td>Dry</td>
</tr>
<tr>
<td>40%</td>
<td>Every Four Days</td>
<td>Very Dry</td>
</tr>
</tbody>
</table>

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each pot containing the same volume of washing sandy soil and peat moss, (1:2 - v: v), the sand culture technique and nutrient solution were similar to those adopted by Hewitt (1952); Hoagland and Arnon (1950) respectively.

**Plant Growth:** Growth measurements were carried out at 3 different growth stages thought the experimental period. These growth stages represented 30, 60 and 90 days old plants and referred vegetative was (growth stage I), flowering was (growth stage II) while fruiting was (growth stage III) of plants respectively, samples for all growth stages were always collected to the least field capacity characteristic of each water treatment as shown in the above scheme and other samples were collected at the highest field capacity. The data of different treatment were statistically analyzed using the least significant difference (L.S.D) at 1% and 5% levels. Three plants of each treatment were washed with distilled water, blotted thoroughly and then divided into root and shoot. The length of each shoot and root were measured (cm/plant), Number of leaves was recorded, and Leaf area (cm²/leaf) assessed using the leaf No. 3 from the lower, by a Portable Area Meter (Area Meter Model CI, 202). The shoot and root fresh after weighing, dried at 80°C reweighed, fresh and dry weights (g/plant) of shoot and root every time harvesting and placing samples fresh in oven for drying at a temperature of 80°C for 72 h until proven weight then was weighing in the balance of digital for dry weight.

**Yield Production (First Generation) of Wheat Plant:** Yield production (First Generation) was assessed as weight of spike per plant (g), Weight of grains per spike (g), Weight of 100 grains (g) (Grain Index), Number of grains per spike, Weight of grains per pot (g), Weight of straw per Pot (g), Harvest Index per Plant.

**Statistical Analysis:**
The data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Kotz, et. al., 2006) Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level (Kirkpatrick & Feeney, 2013). The used tests were as follows:

1. Student t-test: For normally quantitative variables, to compare between two studied groups
2. F-test (ANOVA): For normally quantitative variables, to compare between more than two studied groups, and Post Hoc test (LSD) for pair-wise comparisons
3. Two ways (ANOVA): Was assessed to showing the effect of each factor and the interaction between them (Leslie et at., 1986; Kirkpatrick and Feeney, 2013).

**Results and discussion**

**Germination Rate**
Results presented as shown in Figure(1) &Table (2) indicated that the germination rate (%) of wheat grains increased more in the present of salicylic acid (the grains soaked in +SA) more than in the absent of salicylic acid (the grains soaked in distilled water -SA). Generally, the wheat grains germination occurred after 4 - 5 days (+ SA & - SA respectively), but the germination rate were more faster after soaking the grains in salicylic acid (SA) compared with control (distilled water). Germination is a crucial stage in seedling establishment and plays a key role in crop production. The germination process comprises two distinct phases the first is imbibition, mainly dependent on the physical characteristics of the seeds and the second is a heterotrophic growth phase between imbibition’s and emergence (Khajeh-hosseini et al, 2003; Akbari ghogdi et al., 2012).

The data presented by Khajeh-hosseini et al. (2003); Akbari ghogdi et al. (2012) they found that the germination was a crucial stage in seedling establishment and plays a key role in crop production. Also, the germination process comprises two distinct phases the first is imbibition’s, mainly dependent on the physical characteristics of the seeds and the second is a heterotrophic growth phase between imbibition’s and emergence.

Soltani et al. (2006) expressed that probably reduced germination percentage and seed germination index under low osmotic potential due to endosperm material decompose or slower transfer of this material to the seedling. Sadat Noori et al. (2007) reported that canola seeds that were under stress, more time needed for germination.

The salicylic acid plays a remarkable role in case of seed germination, cell growth under salinity due to its antioxidants properties (Netondo et al., 2004). Seed germination and seedling growth traits are extremely important factors in determining yield (Rauf et al., 2007). Dhandas et al. (2004) indicated that seed vigor index and plumule length are the most sensitive traits to drought stress. The rate of seed germination and the final germination percentage as well as amount of water absorption by seeds were considerably lowered with the rise of osmotic stress level at grain growth (Heikal et al., 1981). There are many studies such as the selecting plant species or the seed treatments that are helpful for alleviating the negative effect of drought stress on different plants (Almansouri et al., 2001; Iqbal and Ashraf, 2007). With respect to the importance of environmental effects on plant productivity the aim of this study was to evaluate the yield and germination characteristics of produced seeds under post-anthesis water deficiency stress in wheat.

The role of salicylic (SA) in grains germination and cell growth under salinity is remarkable its anti-oxidant activity, rather than its possible utility as an organic substrate for respiratory energy metabolism. So, after soaking the wheat grains in salicylic acid (SA), the rate of germination increased with times. The effect of salicylic acid on plant survival is associated with the partial inhibition of a few
interactions in active oxygen species production. An artificial increase in cellular level of an antioxidant such as salicylic acid should be beneficial in improving stress tolerance at germination level (Shalata, and Neumann, 2001; Khan et al., 2006a).

Table 2. Impact of Salicylic Acid (0.5 mM SA) on germination rate of wheat (Triticum aestivum, L. cv. Pavon 76 & cv. Yecora Rojo) grains.

<table>
<thead>
<tr>
<th>Germination Rate (%)</th>
<th>Time / Days</th>
<th>LSD (5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salicylic acid (0.5 mM SA)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Triticum aestivum, L. cv. Pavon 76</td>
<td>-SA</td>
<td>31.0a±E±</td>
</tr>
<tr>
<td></td>
<td>+SA</td>
<td>35.0a±D±</td>
</tr>
<tr>
<td>Triticum aestivum, L. cv. Yecora Rojo</td>
<td>-SA</td>
<td>21.0g±G±</td>
</tr>
<tr>
<td></td>
<td>+SA</td>
<td>23.0e±E±</td>
</tr>
</tbody>
</table>

-SA = Absence of SA, Soaking Grains in distilled water before germinated
+SA= Presence of ASC, Soaking Grains in Salicylic Acid before germinated

Values are expressed as the mean of five samples ± Standard Deviation (±SD)
Statistical Analysis treatments, where relevant, the experimental data were subjected of One – Way analysis of variance (ANOVA). Note: F values *= P < 0.05, ** = P < 0.01, *** = P < 0.001 and N.S. = Not Significant.

Growth Parameters

Generally, water field capacity stress in plants retards all major growth processes that have been examined, the growth parameters decreased significantly with increasing or decreasing water field capacity compared with normal field capacity (100%, 60% & 40%), whereas, the level of growth increased more in the presence of salicylic acid (+SA), compared with control in the present or absent salicylic acid (-SA and +SA), as shown in Figures (2&3) &Tables (3a&b). Wheat plant tended to increased significantly the growth parameters (shoot and root length, leaf number and area, shoot and root fresh and dry weight) in the presence of salicylic acid (+SA) compared to wheat plant control. Overall, wheat plant length tended to decrease with decreasing water field capacity while after soaked the grains of wheat in salicylic acid (+SA) tended to increased plant length in both cultivars. So, soaking grains in salicylic acid (+SA) tended to decrease the effects of water stress with all water field capacity wet, dry and very dry respectively compared with control. The results agree with Ejaz et al. (2012) they found that the leaf area per plant was significantly reduced under salt stress, while salicylic acid (SA) applications markedly improved the inhibitory effects of salt on plants. The fresh weight in four tomato cultivars decreased with osmotic stressed (Ashraf and Harris, 2004; Okhovatian-Ardakani et al., 2010; Ali et al., 2011).

Hence, it is assumed that exogenous salicylic acid (SA) improve grains tolerance to water stress significantly. Water stress reduces plant productivity first by reducing plant growth during the phase of osmotic stress and subsequently by inducing leaf senescence during the phase of toxicity when excessive salt is accumulated in transpiring leaves (Munns, 2002). Water deficits may exert their effects directly on cell extension and division (Greenway and Munns, 1983).

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Salicylic acid (SA)-treatment induces a sharp accumulation of ABA, which in turn is an inducer of a wide spectrum of anti-stress reactions in plants, which is why it is likely that the effect of SA on the increase of ABA lies at the root of the pre-adaptive action of SA to possible stress situations (Sakhabutdinova, et al., 2003). The role of salicylic acid on growth parameters it was reported that the

The data presented by Sakhabutdinova, et al. (2003) indicated the total overall that pre-sowing treatment of wheat grains with SA contributes to the increase in the resistance of plants to stress factors of environment and ABA serves as a mediator in the manifestation of the protective action of salicylic acid (SA). Growth of Camellia plants in a 10-1000 μM concentration range of salicylic acid (SA) exhibited an optimum curve. Optimal concentration of SA for leaves growth was 50 μM that caused a twofold significant increase (p<0.05) in leaf area, fresh weight and dry weight.

Table 3 a. Interactive effects of Salicylic Acid (SA) and water stress Treatments on Shoot and Root Length (cm/plant), Leaf Area (cm²) and Number, Shoot and Root Fresh and Dry Weight (g/Organ) of wheat (Triticum aestivum, L. cv. Pavon 76) Plant. The leaf Area was Estimated in The 5th Leaves from the Shoot Top.

<table>
<thead>
<tr>
<th>Triticum aestivum, L cv. Pavon 76, W.F.C. (%)</th>
<th>Shoot Length (cm/Plant)</th>
<th>Root Length (cm/Plant)</th>
<th>Leaf Area (cm²/leaf)</th>
<th>Number of Leaves / Plant</th>
<th>Shoot Fresh Weight (g/Plant)</th>
<th>Root Fresh Weight (g/Plant)</th>
<th>Shoot Dry Weight (g/Plant)</th>
<th>Root Dry Weight (g/Plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-SA 100%</td>
<td>40.48°C±0.79</td>
<td>19.53°C±0.80</td>
<td>19.53°C±0.80</td>
<td>10.3bcB±0.58</td>
<td>56.81°C±0.57</td>
<td>3.27A±0.58</td>
<td>6.91B±0.58</td>
<td>0.70bA±0.09</td>
</tr>
<tr>
<td>80%</td>
<td>42.49±B±0.80</td>
<td>25.35±C±0.43</td>
<td>38.66±C±0.57</td>
<td>12.0B±0.57</td>
<td>62.72±C±0.57</td>
<td>3.48A±0.58</td>
<td>7.07B±0.55</td>
<td>0.69bcA±0.06</td>
</tr>
<tr>
<td>60%</td>
<td>36.07±C±0.61</td>
<td>26.21±C±0.50</td>
<td>29.12°C±0.58</td>
<td>12.7B±0.58</td>
<td>57.32°C±0.58</td>
<td>3.21A±0.57</td>
<td>7.54B±0.82</td>
<td>0.61A±0.06</td>
</tr>
<tr>
<td>40%</td>
<td>25.10±C±0.56</td>
<td>27.88±C±0.51</td>
<td>22.81±C±0.57</td>
<td>11.3bcB±0.58</td>
<td>52.51±C±0.57</td>
<td>3.0A±0.58</td>
<td>7.67B±0.57</td>
<td>0.55A±0.06</td>
</tr>
<tr>
<td>+SA 100%</td>
<td>43.86±C±0.60</td>
<td>20.55±B±0.83</td>
<td>38.80±C±0.57</td>
<td>10.7B±0.63</td>
<td>66.18±C±0.57</td>
<td>3.57A±0.58</td>
<td>7.38B±0.58</td>
<td>0.81A±0.06</td>
</tr>
<tr>
<td>80%</td>
<td>47.12±C±0.53</td>
<td>26.72±C±0.58</td>
<td>41.80±C±0.57</td>
<td>11.12±B±0.59</td>
<td>71.12±C±0.53</td>
<td>4.47A±0.57</td>
<td>8.19B±0.58</td>
<td>0.98A±0.06</td>
</tr>
<tr>
<td>60%</td>
<td>39.61±C±0.35</td>
<td>28.61±C±0.35</td>
<td>29.11±C±0.53</td>
<td>10.8bcA±0.67</td>
<td>64.06±C±0.58</td>
<td>3.91A±0.57</td>
<td>8.31B±0.57</td>
<td>0.81bcA±0.06</td>
</tr>
<tr>
<td>40%</td>
<td>33.19°C±0.58</td>
<td>29.01°C±0.59</td>
<td>25.18±C±0.57</td>
<td>10.2A±0.58</td>
<td>60.0°C±0.58</td>
<td>3.61A±0.57</td>
<td>8.21B±0.58</td>
<td>0.80bA±0.06</td>
</tr>
</tbody>
</table>

LSD (5%) 1.848 1.784 1.709 1.799 1.706 1.727 1.829 0.187

ASC = Absence of ASC, Soaking Seeds in distilled water before germination +ASC = Presence of ASC, Soaking Seeds in Ascorbic Acid before germination Values are expressed as the mean of five samples ± Standard Deviation (±SD) Statistical Analysis treatments, where relevant, the experimental data were subjected of One – Way analysis of variance (ANOVA). Note: F values * = P > 0.05, ** = P > 0.01, *** = P > 0.001 and N.S. = Not Significant.
Salicylic acid set the expansion division and cell death (Zhang et al., 2002). Furthermore, salicylic acid was found to regulate many physiological processes and plant growth (Senaratna et al., 2002; Traw and Bergelson, 2003; Zhang et al., 2004). Also it is reported that salicylic acid causes plant adaptation upon environmental stress (Shah et al., 2002).

**Shoot and Root Length (cm/Plant):** The data presented in Figures (2) & Tables (3a&b) shown that in the absence of salicylic acid (- SA), the shoot length decreased significantly ($P \leq 0.001$) with all water field capacity stress, wet (100%), dry (60%) & very dry (40%) compared with control 80% with all growth stages (I, II & III) for both cultivars (cv. Pavon 76 & cv. Yecora Rojo). The reduction rate noticed more in dry and very dry stress (60% & 40% WFC) respectively more than the wet stress (100% WFC) compared with control (80% WFC), the reducing ratio degradation from vegetative to fruiting stage (I, II & III) respectively in the absence of salicylic acid (- SA) significantly ($P \leq 0.001$) more than in the presence of salicylic acid (+ SA). Overall the statistical analysis indicated that the two ways analysis of variance (ANOVA) between different water field capacity stress in each cultivars at all growth stages in the presence or absent of salicylic acid (- SA & + SA) indicated that the LSD test highly significant at $P \leq 0.001$.

![Figure (3): Interactive Effect of Salicylic acid (0.5 mM) and Water Stress on Shoot and Root Fresh and Dry Weights (mg/Plant) of Wheat (Triticum aestivum, L. cv. Pavon 76 and cv. Yecora Rojo) Plant at Fruiting Growth Stage (III) Grown Under Greenhouse Conditions, Before Irrigation.](image)

Dhanda et al. (2004) indicated that seed vigor index and plumule length are among the other germination traits are most sensitive to drought stress. Spielmeyer et al. (2007) reported that, wheat of more powerful early vigor quickly covered of the soil surface that due to competition power increase with weeds and reduce loss of water. Results of statistical analysis showed that non-correlation were observed between grain weight and vigor, but Ries and Everson (1973) reported that seed size is positively correlated with seed vigor.

The data presented by Sakhabutdinova, et al. (2003), maintaining a high level of ABA in SA-treated plants under stress contributes to protective reactions aimed to decrease its injurious effect on growth and acceleration of growth resumption. Overall the statistical analysis indicated that the three ways analysis of variance (ANOVA) between different water field capacity stress in each cultivars at all growth stages in the presence or absent of salicylic acid (- SA & + SA) indicated that the LSD test highly significant at $P \leq 0.001$.

Almaghrabi (2012) reported in general radicle length was decreasing significantly with increasing of PEG concentration. Fraser et al. (1994) concluded that the reduction in the radicle length under drought stress may due to an impediment of cell division and elongation is depended on the kind tuberization. Badiow et al. (2004) with study of development of the radicle system in response to water deficit suggests that the expression of certain genes controlling radicle formation that stimulated by drought conditions. In addition to dominant alleles due to control of the length of radicles and the feature that could be easily incorporated in breeding for drought resistance (Vijendradas, 2000).

**Leaf Area (cm$^2$/leaf):**

Overall, the result presented in Figures (2) & Tables (3a&b) showed that the Leaf area in wheat (Triticum aestivum, L.) plant for both cultivars (cv. Pavon 76 & cv. Yecora Rojo) affected by all water field capacity stress (wet, dry and very dry stress). Generally the results showed that the decreased significantly ($p < 0.001$) in the leaf area of wheat (Triticum aestivum, L.) plant for both cultivars (cv. Pavon 76 & cv. Yecora Rojo) with all water field capacity stress (100%, 60% & 40%) compared with control (normal field capacity 80%). Whereas, in the present of salicylic acid (+ SA) the statistical analysis indicated that the leaf area increased significantly ($p \leq 0.001$) with different water field capacity stress at all growth stages (vegetative, flowering and fruiting stages) more than in the absent of salicylic acid (- SA). Whereas, in the presence of salicylic acid (+ SA), the leaf area tended to increased significantly ($P \leq 0.001$).
compared with absent of salicylic acid (- SA), at all growth stage (\( P \leq 0.001 \)). Overall the statistical analysis indicated that the two ways analysis of variance (ANOVA) between different water field capacity stress in each cultivars at all growth stages in the presence or absent of salicylic acid (- SA & + SA) indicated that the LSD test highly significant at \( P \leq 0.001 \).

Table 3b. Interactive effects of Salicylic Acid (SA) and water stress Treatments on Shoot and Root Length (cm/plant), Leaf Area (cm\(^2\)) and Number, Shoot and Root Fresh and Dry Weight (g/Organ) of wheat (Triticum aestivum, L. cv. Yecora Rojo) Plant. The leaf Area was Estimated in the 5\(^{th}\) Leaves From the Shoot Top.

<table>
<thead>
<tr>
<th>Triticum aestivum, L. cv. Yecora Rojo</th>
<th>Shoot Length (cm/Plant)</th>
<th>Root Length (cm/Plant)</th>
<th>Leaf Area (cm(^2)/leaf)</th>
<th>Number of Leaves / Plant</th>
<th>Shoot Fresh Weight (g/Plant)</th>
<th>Root Fresh Weight (g/Plant)</th>
<th>Shoot Dry Weight (g/Plant)</th>
<th>Root Dry Weight (g/Plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W.F.C. (%)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>-SA</td>
<td>36.55(^{BC}) ± 0.3</td>
<td>18.61(^{B}) ± 0.85</td>
<td>36.02(^{C}) ± 0.58</td>
<td>8.65(^{A}) ± 0.66</td>
<td>45.17(^{C}) ± 0.57</td>
<td>3.17(^{A}) ± 0.58</td>
<td>4.82(^{A}) ± 0.57</td>
<td>0.58(^{A}) ± 0.06</td>
</tr>
<tr>
<td></td>
<td>8</td>
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<tr>
<td>80%</td>
<td>40.41(^{B}) ± 0.84</td>
<td>26.04(^{C}) ± 0.58</td>
<td>39.67(^{C}) ± 0.57</td>
<td>9.3(^{A}) ± 0.61</td>
<td>67.07(^{C}) ± 0.6</td>
<td>3.20(^{A}) ± 0.5</td>
<td>5.90(^{A}) ± 0.5</td>
<td>0.62(^{A}) ± 0.0</td>
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<tr>
<td>(C)</td>
<td></td>
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<tr>
<td>60%</td>
<td>34.80(^{B}) ± 0.58</td>
<td>25.09(^{C}) ± 0.54</td>
<td>30.89(^{C}) ± 0.57</td>
<td>9.0(^{A}) ± 0.58</td>
<td>53.71(^{C}) ± 0.5</td>
<td>3.07(^{A}) ± 0.5</td>
<td>5.33(^{B}) ± 0.52</td>
<td>0.60(^{B}) ± 0.0</td>
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<tr>
<td>+SA</td>
<td>27.13(^{C}) ± 0.54</td>
<td>20.08(^{B}) ± 0.5</td>
<td>28.43(^{C}) ± 0.5</td>
<td>8.8(^{A}) ± 0.68</td>
<td>49.15(^{B}) ± 0.5</td>
<td>3.01(^{A}) ± 0.5</td>
<td>5.01(^{A}) ± 0.5</td>
<td>0.57(^{A}) ± 0.0</td>
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<tr>
<td>100%</td>
<td>39.19(^{C}) ± 0.57</td>
<td>20.31(^{B}) ± 0.57</td>
<td>32.32(^{B}) ± 0.5</td>
<td>9.3(^{B}) ± 0.57</td>
<td>45.11(^{C}) ± 0.6</td>
<td>2.61(^{A}) ± 0.5</td>
<td>5.01(^{A}) ± 0.5</td>
<td>0.76(^{A}) ± 0.0</td>
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<td>(C)</td>
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<tr>
<td>80%</td>
<td>42.13(^{C}) ± 0.57</td>
<td>28.13(^{C}) ± 0.57</td>
<td>43.18(^{C}) ± 0.57</td>
<td>10.0(^{A}) ± 0.5</td>
<td>69.91(^{C}) ± 0.57</td>
<td>3.33(^{A}) ± 0.6</td>
<td>6.31(^{A}) ± 0.58</td>
<td>0.98(^{B}) ± 0.09</td>
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<tr>
<td>(C)</td>
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<tr>
<td>60%</td>
<td>36.81(^{B}) ± 0.57</td>
<td>28.64(^{C}) ± 0.34</td>
<td>28.21(^{C}) ± 0.5</td>
<td>9.7(^{A}) ± 0.84</td>
<td>55.18(^{C}) ± 0.5</td>
<td>3.88(^{A}) ± 0.5</td>
<td>5.98(^{B}) ± 0.5</td>
<td>0.75(^{B}) ± 0.0</td>
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<td>(C)</td>
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<tr>
<td>40%</td>
<td>29.89(^{C}) ± 0.57</td>
<td>29.12(^{C}) ± 0.53</td>
<td>24.13(^{B}) ± 0.58</td>
<td>9.2(^{A}) ± 0.57</td>
<td>50.89(^{C}) ± 0.5</td>
<td>3.13(^{A}) ± 0.5</td>
<td>5.32(^{B}) ± 0.6</td>
<td>0.78(^{B}) ± 0.06</td>
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<tr>
<td>LSD (5%)</td>
<td>1.764</td>
<td>1.751</td>
<td>1.729</td>
<td>1.922</td>
<td>1.756</td>
<td>1.765</td>
<td>1.737</td>
<td>0.173</td>
</tr>
</tbody>
</table>

- ASC = Absence of ASC, Soaking Seeds in distilled water before germinated
+ ASC = Presence of ASC, Soaking Seeds in Ascorbic Acid before germinated
Values are expressed as the mean of five samples ± Standard Deviation (±SD)

Statistical Analysis treatments, where relevant, the experimental data were subjected of One – Way analysis of variance (ANOVA). Note: \( P \) values *\( = P > 0.05 \), **\( = P > 0.01 \), ***\( = P > 0.001 \) and N.S. = Not Significant.

Leaf Number:
Overall, the result presented in Figures (2) & Tables (3a&b) showed that the Leaf number of wheat (Triticum aestivum, L.) plant for both cultivars (cv. Pavon 76 & cv. Yecora Rojo) affected significantly (\( P \leq 0.001 \)) by all water field capacity stress (100%, 80% & 60% & 40%). Generally the results presented here showed that the leaf number of wheat (Triticum aestivum, L.) plant for both cultivars (cv. Pavon 76 & cv. Yecora Rojo) decreased significantly (\( P < 0.001 \)) with all water field capacity stress (100% wet, 60% dry & 40% very dry) compared with control (80% normal water field capacity). Whereas, in the present of salicylic acid (+ SA) the statistical analysis indicated that the leaf number decreased significantly (\( P \leq 0.001 \)) with different water field capacity stress at all growth stages (vegetative, flowering and fruiting stages) more than in the absent of salicylic acid (- SA). Whereas, in the present of salicylic acid (+ SA), the leaf number tended to increased significantly (\( P \leq 0.001 \)) compared with absent of salicylic acid (- SA), at all growth stage. Overall the statistical analysis indicated that the two ways analysis of variance (ANOVA) between different water field capacity stress in each cultivars at all growth stages in the presence or absent of salicylic acid (- SA & + SA) indicated that the LSD test highly significant at \( P \leq 0.001 \).

Shoot and Root Fresh and Dry Weights (g/plant):
Overall, shoot and root fresh and dry weights of wheat (Triticum aestivum, L.) plant for both cultivars (cv. Pavon 76 & cv. Yecora Rojo) decreased significantly (\( P \leq 0.001 \)) with all water field capacity stress 100% wet, 60% dry and 40% very dry treatments compared with control (80%) at all growth stages for both cultivars before and after irrigation as shown in Figures (3) & Tables (3a&b). So, the fresh weights of shoot and root increased significantly (\( P \leq 0.001 \)) after irrigation more than before irrigation, also the fresh weight increased significantly (\( P \leq 0.001 \)) in the present of salicylic (+ SA) more than in the absent of salicylic acid (- SA) (\( P \leq 0.001 \)).

Bonfil et al., (2004) reported that drought stress during grain filling prevents the accumulation of starch in wheat grain and reduce the grain weight. Also, in various studies the effect of reserves and seed size on the characteristics of seed germination, growth and yield of different crops have been studied and usually showed that larger seed resulted to the high germination, seedling powerful growth and ultimately more yield (Erickson, 1946; Eman, 2007). But Mian and Nafziger (1992) concluded that seed size has little effect on the emergence of winter wheat.
Drought stress cause reductions of shoot and root dry weights in wheat plants for both cultivars, while the presence of salicylic acid (+SA) alleviated drought stress damages on shoot and root dry weight for two cultivars before and after irrigation. These results are in agreement with those reported by others (Baghizadeh, 2009).

These results are agreement with those reported by Baghizadeh (2009).Singh and Usha (2003) suggested that increase in dry mass for water field capacity stressed plants in response to salicylic acid (SA) may be related to the induction of antioxidant responses that protect the plant from damage, the dry weight was reduced by due to water stress.

In this study, we investigated the interactive effect of salicylic acid and drought on two wheat cultivars (tolerance and sensitive). The results from the current study also showed significant improvement of final vegetative growth of wheat and whole plant fresh weight. Drought is an important factor that could influence the growth and physiological characteristics of plants (Ren, 2007; Xiangwen, 2009). The responses of plants to drought stress depend on the species and genotype, the length and severity of water deficit and the age and stage of development (Bray, 1997). It is known that water deficit results in a decline in metabolic activity of plants which should be inevitably reflected in inhibition of their growth (Amin et al., 2009).

On the other hand, the excessive supply of water field capacity, 100% (Wet treatment) appeared in general, to stimulated the growth parameter of shoots and shoot lengths, shoot and root fresh and dry weights, number and leaf area for cv. Pava 76 of Triticum aestivum plants either significantly or non-significantly as compared with the control 100% water field capacity values throughout the experimental stages of the plants growth. In this connection, El Shahaby (1981) found that the water stress induced by water logging led to a dominant decrease in leaf area throughout the different growth stages by using Vigna sinensis plant.

The present rustles are conformity with those reported by Pearson (1965; 1974) who found that more root growth occurred in dry field capacity stress than in wet field capacity stress soil at the normal field capacity. In such soil, poor aeration may have retarded root growth. Whereas the dry soil was not dry enough to seriously limit root growth. On the other hand, Kaufman (1968) showed that the growth of ladally pine roots in soil with a root potential which was allowed to decrease to -6 and -7 bars was only one fourth to growth of roots in soil kept near field capacity.

Bradford and Al Sias (1983) who stated the restriction of shoot growth and continuation of root growth are both important adaptation of water stress, since abscisic acid is a potent inhibitor of shoot growth, accumulation of abscisic acid during water stress may participated in this development adaptation. The water stress as induced by water regime (dry treatments) and wet water treatment has been found, in general to decrease fresh and dry weights of shoots and roots of wheat plants either before and after watering. It is interesting to mention that after irrigation, the decline in the fresh and dry weights of shoots and roots was reduced. In accord with this Marei (1975) observed that the fresh and dry with of shoots and root responded greatly to moisture stress. Thus progressive gradual decreases in fresh and dry weight of shoots and roots were observed with progressive increase in water stress. The wet treatment appeared, in general, to increase the fresh and dry weight of shoots and roots thought the experimental stages. El Shahaby (1980) found that the similar results were obtained by Vigna sinesis plants.

Singh and Usha (2003) reported that foliar spray with salicylic acid (SA) counteracted growth inhibition in wheat caused by water stress, one of the major factors caused by salinity stress in plants. Gutierrez–Coronado et al. (1998) observed significant effects of salicylic acid (SA) on soybean increases in shoot and root growth and plant height. The prevention of water loss from the leaves of drought stressed shallot plants as results of salicylic acid (SA) application might be the principal reason for the significant increase in shoot fresh weight. Davenport et al. (1992) observed that the growth shallot plants increase significantly under drought stressed this resulting from salicylic acid (SA) (anti-transpirant) may due to its effect on improvement of turgidly at a time when the growth of that particular plant part was more dependent on water status than in photosynthesis.

The Role of Salicylic acid (SA) On Yield Production (First Generation) of Wheat Plant Under Water Field Capacity Stress Conditions:

Overall, the yield production (first generation) of wheat plants with both cultivars (cv. Pavon 78 & cv. Yecora Rojo) increased significantly ($P \leq 0.05$) in the present of salicylic acid (+SA) more than in the absence of salicylic acid (-SA) at fruiting stage especially in dry (60%) and very dry (40%) water field capacity compared with wet treatment (100%) in the present of control (80%). Gomes et al. (1993) observed an improvement in plant biomass and yield of wheat genotypes under water stress with salicylic acid (SA) application. Effect of water stress may have significant implications in improving plant growth and overcoming the yield barrier arising from conditions of limited water availability (Gomes et al., 1993).

Weight of Spike /Plant (gm):

Overall, the weight of spike /Plant (gm) for both cultivars (cv. Pavon 76 & cv. Yecora Rojo) of wheat plant decreased significantly ($P \geq 0.05$) with increasing in the water field capacity 100% (wet treatments), the responses varying according to cultivars, weight of spike /plant (g) increasing with decreasing in water field capacity (60% & 40%) especially at fruiting stage. The data presented here shown that the weight of spike/plant increased in cv. Pava 76 more than in cv Yecora Rojo, also, the increasing more in the present of salicylic acid (+SA) more than in the absent of salicylic acid (-SA)as shown in Figures (4)& Tables(4 a&b). Overall the two ways
The findings of the current study are consistent with those of Moral et al. (2002) who found that also negative correlation between these two cultivars. They concluded that this negative correlation is related to compensation effect of yield components on each other. In this situation, by increasing the number of grain/spike, plants cannot fill all of them and then this caused shrinking of grains and finally caused weight loss of the grains. The harvest index can be expressed as ability of plants to allocate photosynthetic material to produce economic yield. In terms of this trait under control and post-anthesis water deficiency stress, there was significant variation between cultivars.

**Weight of grains/spike (g):**

Overall, the differences occurred in the weight of grains / spike (g) were found in wheat plant between both cultivars (cv. Yecora Rojo & cv. Pavon 76) whereas, varying according to water field capacity stress conditions 100%, 60%, & 40% (wet, dry or very dry) respectively. The increasing in the water field capacity 100% (wet treatments), the weight of gains /spike (g) significantly decreased ($P \leq 0.05$) but increasing with decreasing in water field capacity (60% & 40%) especially at fruiting stage ($P \leq 0.05$). The data presented here shown that the weight of gains/ spike increased in cv. Pava 76 more than in cv Yecora Rojo, also, the increasing more in the present of salicylic acid (+ SA) more than in the absent of salicylic acid (- SA) as shown in Figures (5) & Tables (4 a & b). Overall the two ways analysis of variance ($ANOVA$) between different cultivars in each water stress treatments at all growth stages indicated that the $LSD$ test highly significant at $P \leq 0.001$.

The largely due to more significant reduction in grain yield production than biomass production (Shafazadeh et al., 2004). In Richards et al. (2002) demonstrated that for this reason that harvest index is indicators of the genetic potential of plant to produce economic yield, high harvest index under control treatment can be accompanied with high grain yield under water stress. The findings of the current study are consistent with those of Reynolds et al. (2009) who found wheat cultivars that have high biological yield and harvest index, most likely have high grain yield under stress and control conditions.

**Weight of 100 grains (g) (Grain Index):**

Overall, the grain index varied with Wheat ($Triticum aestivum$, L.) cultivars (cv. Yecora Rojo & cv. Pavon 76) and significantly decreased ($P \leq 0.05$) with increasing water field capacity stress, wet treatments (100%) at fruiting stage, especially in the absent of salicylic acid (- SA) the more decreasing occurred, as shown in Figures (6) & Tables (4 a & b). Overall the two ways analysis of variance ($ANOVA$) between different cultivars in each water stress treatments at all growth stages indicated that the $LSD$ test highly significant at $P \leq 0.001$.

In post anthesis water deficiency, a positive correlation was found between grain weight and harvest index. It means that increasing of grain weight is accompanied with increasing harvest index (Koocheki et al., 2006).

**Number of grains/spike:**

The number of grains/spike was influenced by water field capacity stress (100%, 60% & 40%) compared with control (80%), with both cultivars (cv. Yecora Rojo & cv. Pavon 76), of wheat plant. The number of grains/spike decreased significantly ($P \leq 0.001$) with increasing water field capacity stress (100%) especially in the present of salicylic acid (+ SA), as shown in Figures (7) & Tables (4 a & b). Overall the two ways analysis of variance ($ANOVA$) between different cultivars in each water stress treatments at all growth stages indicated that the $LSD$ test highly significant at $P \leq 0.001$. 

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Between control and post-anthesis water deficiency conditions in terms of the number of spike/plant and number of grain/spike were no significant differences. This result is probably because the potential of these components are formed before spick initiation, so post anthesis water deficiency stress has no significant influence on them (Araus et al. 2002; Tavakoli et al., 2009; Abdoli and Saeidi, 2012).

**Figure (7):** Interactive Effect of Salicylic acid (0.5 mM) and Water Stress on Number of grains/spike of Wheat (Triticum aestivum, L. cv. Pavon 76 and cv. Yecora Rojo) Yield Productive Grown Under Green House Conditions.

**Figure (5):** Interactive Effect of Salicylic acid (0.5 mM) and Water Stress on Weight of grains/spike (gm) of Wheat (Triticum aestivum, L. cv. Pavon 76 and cv. Yecora Rojo) Yield Productive Grown Under Green House Conditions.
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Figure (6): Interactive Effect of Salicylic acid (0.5 mM) and Water Stress on Weight of 100 grains (gm) of Wheat (*Triticum aestivum*, L. cv. Pavon 76 and cv. Yecora Rojo) Yield Productive Grown Under Green House Conditions.

Table 4 a: Interactive Effects of Salicylic Acid (SA) and Water Stress Treatments on Yield Production of Wheat (*Triticum aestivum*, Lcv. Pavon 76) Plant.

<table>
<thead>
<tr>
<th>Triticum aestivum, L cv. Pavon 76</th>
<th>Weight of spike/Plant (gm)</th>
<th>Weight of grains/spike (gm)</th>
<th>Weight of 100 grains (gm)</th>
<th>Number of grains/spike</th>
<th>Weight of grains/Pot (gm)</th>
<th>Weight of straw /Pot (gm)</th>
<th>Harvest Index /Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>-SA 100%</td>
<td>2.08 ± 0.09</td>
<td>0.99 ± 0.04</td>
<td>4.60 ± 0.05</td>
<td>21.34 ± 0.73</td>
<td>66.63 ± 0.39</td>
<td>21.44 ± 0.45</td>
<td>47.31 ± 0.20</td>
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<tr>
<td>80% □</td>
<td>2.79 ± 0.04</td>
<td>2.18 ± 0.02</td>
<td>10.83 ± 0.05</td>
<td>36.93 ± 0.90</td>
<td>113.26 ± 1.33</td>
<td>24.38 ± 0.41</td>
<td>76.43 ± 0.73</td>
</tr>
<tr>
<td>60%</td>
<td>2.32 ± 0.06</td>
<td>2.11 ± 0.03</td>
<td>10.80 ± 0.30</td>
<td>35.40 ± 0.37</td>
<td>106.00 ± 1.25</td>
<td>22.25 ± 0.45</td>
<td>91.34 ± 0.34</td>
</tr>
<tr>
<td>+SA 40%</td>
<td>2.09 ± 0.05</td>
<td>2.01 ± 0.06</td>
<td>10.33 ± 0.30</td>
<td>32.31 ± 0.37</td>
<td>100.4 ± 1.25</td>
<td>20.04 ± 0.34</td>
<td>95.30 ± 0.32</td>
</tr>
<tr>
<td>100%</td>
<td>2.38 ± 0.02</td>
<td>1.36 ± 0.02</td>
<td>5.44 ± 0.19</td>
<td>25.99 ± 0.64</td>
<td>81.82 ± 0.38</td>
<td>27.36 ± 0.34</td>
<td>56.41 ± 0.38</td>
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<tr>
<td>80% □</td>
<td>3.03 ± 0.05</td>
<td>2.35 ± 0.02</td>
<td>13.69 ± 0.30</td>
<td>46.26 ± 0.40</td>
<td>139.7 ± 0.68</td>
<td>27.74 ± 0.37</td>
<td>79.43 ± 0.37</td>
</tr>
<tr>
<td>60%</td>
<td>2.57 ± 0.03</td>
<td>2.17 ± 0.02</td>
<td>13.73 ± 0.30</td>
<td>39.45 ± 0.68</td>
<td>117.8 ± 0.81</td>
<td>23.83 ± 0.34</td>
<td>85.08 ± 0.58</td>
</tr>
<tr>
<td>40%</td>
<td>2.34 ± 0.01</td>
<td>2.26 ± 0.02</td>
<td>14.18 ± 0.30</td>
<td>37.33 ± 0.78</td>
<td>107.7 ± 0.81</td>
<td>21.67 ± 0.34</td>
<td>89.64 ± 0.38</td>
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<td>0.10 ± 0.01</td>
<td>0.49 ± 0.07</td>
<td>2.09 ± 0.09</td>
<td>1.02 ± 0.02</td>
<td>0.42 ± 0.04</td>
<td>1.113 ± 0.04</td>
<td>0.64 ± 0.04</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>0.178 ± 0.014</td>
<td>1.495 ± 0.05</td>
<td>2.049 ± 0.05</td>
<td>1.113 ± 0.04</td>
<td>0.42 ± 0.04</td>
<td>1.113 ± 0.04</td>
<td>0.64 ± 0.04</td>
</tr>
</tbody>
</table>

-ASC = Absence of ASC, Soaking Seeds in distilled water before germinated
+ASC = Presence of ASC, Soaking Seeds in Ascorbic Acid before germinated
Values are expressed as the mean of five samples ± Standard Deviation (±SD)
Statistical Analysis treatments, where relevant, the experimental data were subjected of One – Way analysis of variance (ANOVA). Note: F values *= P < 0.05, ** = P < 0.01, *** = P < 0.001 and N.S.= Not Significant.

Weight of grains/pot (g):
The weight of grains/pot differed according to species of wheat for both cultivars (cv. Pavon 76 & cv. Yecora Rojo). The response of grains weight /pot to water field capacity stress varied according to the treatment for wet, dry & very dry (100%, 60% & 40%) respectively compared with control (80%). The weight of grain/ pot (g) decreased significantly (P ≤ 0.001) with increasing water field capacity stress (100%). The weight of grain / pot (g) increased significantly (P ≤ 0.05) with cv. Pavon 76 more than Yecora Rojo especially in the present of salicylic acid (+ SA), as shown in Figures (8) & Tables (4 a&b). Overall the two ways analysis of variance (ANOVA) between different cultivars in each water stress treatments at all growth stages indicated that the LSD test highly significant at P ≤ 0.001.
The findings from Saeidi et al., (2010) when they imposed water deficit at different stages of grain growth separately, showed that significant reduction in grain yield production in these conditions may be result of reducing the production of photo-assimilates (source limitation) for grain filling, reducing the sink power in absorbing of photo-assimilates and reducing the grain filling duration. They also reported that probably, the early processes of grain growth (cell division and formation of sink size) are less affected by water deficiency. Therefore, grain weight and grain yield reduction under post-anthesis water deficiency may be more reflects the lack of photo-assimilates supply for grain filling. These findings also are in agreement with Emam and Niknejad (2004); Ehdaie et al. (2006), Ahmadi et al. (2009).

Overall, the weight of straw / pot (g) influenced by water field capacity stress (100%, 60% & 40%) compared with control (80%), with wheat plant for both cultivars (cv. Pavon 76 & cv. Yecora Rojo). The weight of straw / pot (g) decreased significantly ($P \leq 0.001$) with increasing water field capacity stress (100%). The weight of straw / pot (g) increased significantly ($P \leq 0.05$) with cv. Pavon 76 more than Yecora Rojo especially in the present of salicylic acid (+ SA), as shown in Figures (9) & Tables (4 a&b). Overall the two ways analysis of variance (ANOVA) between different cultivars in each water stress treatments at all growth stages indicated that the LSD test highly significant at $P \leq 0.001$. 

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Harvest Index /Plant:

Overall, the harvest index/plant influenced by water field capacity stress (100%, 60% & 40%) compared with control (80%), with wheat plant for both cultivars (cv. Pavon 76 & cv. Yecora Rojo). The harvest index/plant decreased significantly ($P \leq 0.05$) with increasing water field capacity stress (100%). The harvest index / plant increased significantly ($P \leq 0.05$) with cv. Pavon 76 more than Yecora Rojo especially in the present of salicylic acid (+ SA), as shown in Figures (10) & Tables (4 a&b). Overall the two ways analysis of variance (ANOVA) between different cultivars in each water stress treatments at all growth stages indicated that the LSD test highly significant at $P \leq 0.001$.

Exogenous application of salicylic acid (SA) appeared to improve the growth vigor of *Triticum aestivum* plants by enhancing shoot length, root length and plant fresh and dry weight. These results can be related to earlier studies which observed that exogenous application of salicylic acid (SA) promotes growth and counteracts the stress induced growth inhibition due to abiotic stresses in a range of crop species (Tariet al., 2002; Shakirova et al., 2003; Singh and Usha, 2003; Khodary, 2004; El- Tayeb, 2005; Arfan et al., 2007).

Shakirova et al. (2003) reported that, the treatment of wheat plants with 0.05mM salicylic acid (SA) increased the level of cell division within the apical meristem of seedling roots causing an increase in plant growth and elevated wheat productivity. Arfan et al. (2007) investigate that the improvement in growth and grain yield of wheat water stress due to SA application. Moreover, under non stress conditions the increase in plant final yield has been reported for many crop species including staff flower (Ebrahimzadeh et al., 2009) and many vegetable crop (Hayatand Ahamed, 2007).

Generally, our results showed that various wheat cultivars differently responded to water stress in terms of yield and germination traits. With regard to farm and laboratory results, it can be seen that Pavon 76 cultivar, with possess the highest grain yield and 100 grain weight, had the best germination characteristics and less affected by post-anthesis water deficiency stress during grain growth, also Yecora Rojo were the next cultivars based on germination characteristics. The high yield of plant in sufficient irrigated conditions is not necessarily correlated to high yield under drought stress (Vahidi, 2009). Depending on which stage of growth a plant experiences drought stress, it reacts quite differently to the stress (Galies and Ho, 1983). A common adverse effect of water stress on crop plants is reducing of fresh and dry biomass production (Faroq et al., 2009).

Plant productivity under drought stress is strongly related to the processes of dry matter partitioning and temporal biomass distribution (Kage et al., 2004). The sensitivity of crop plants such as wheat (*Triticum aestivum* L.) to soil drought is particularly acute during the grain-filling period because the reproductive phase is extremely sensitive to plant water stress. It affects both elongation and expansion growth (Kusaka et al., 2005; Shao et al., 2008).
Generally, using SA treatment increased the plant healthy and increased the yield production. It suggests that SA could stimulate defense system for water stress. 

Conclusion
The current study of these Results showed that the positive impacts of salicylic acid (SA) on germination, growth parameters of wheat plant for both cultivars as well as water field capacity treatments than control. So, a simple and safe method, soaking the grains of wheat plant before planting can be used to improve the plant growth and water efficiency. It appears that utilization of SA can lead to improve quantity and quality of wheat (Triticum aestivum, L. cv. Pavon 76 & Yecora Rojo) plant by decreased the plant length but increased the plant healthy and increased the yield production. It suggests that SA could stimulate defense system for water-stress. Generally, using SA treatment could be a promising technique for agricultural improvements but extensive research is required on different crops.

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References

Table 4 b. Interactive Effects of Salicylic Acid (SA) and Water Stress Treatments on Yield Production of Wheat (Triticum aestivum, L. cv. Yecora Rojo) Plant.

<table>
<thead>
<tr>
<th>Triticum aestivum, L cv. Yecora Rojo SA 0.5 mM - W.F.C. (%)</th>
<th>Weight of spike/Plant (g)</th>
<th>Weight of grains/spike (g)</th>
<th>Weight of 100 grains (g)</th>
<th>Number of grains/spike</th>
<th>Weight of grains/Pot (g)</th>
<th>Weight of straw/Pot (g)</th>
<th>Harvest Index/Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>-SA</td>
<td>100%</td>
<td>1.02±0.06</td>
<td>0.60±0.03</td>
<td>2.75±0.12</td>
<td>20.01±0.50</td>
<td>56.49±0.47</td>
<td>56.41±0.46</td>
</tr>
<tr>
<td>80%</td>
<td>2.16bc*±0.09</td>
<td>1.62b±0.06</td>
<td>7.13b±0.14</td>
<td>33.73b±0.83</td>
<td>94.77b±0.77</td>
<td>75.10±0.52</td>
<td>75.10±0.52</td>
</tr>
<tr>
<td>60%</td>
<td>2.04cd±0.09</td>
<td>1.69bc±0.02</td>
<td>8.35bc±0.35</td>
<td>29.78±0.36</td>
<td>85.55bc±0.97</td>
<td>84.88±0.32</td>
<td>84.88±0.32</td>
</tr>
<tr>
<td>40%</td>
<td>1.87de*±0.03</td>
<td>1.48c±0.04</td>
<td>7.16c±0.17</td>
<td>27.08±0.49</td>
<td>80.52c±0.43</td>
<td>76.81c±0.59</td>
<td>76.81c±0.59</td>
</tr>
<tr>
<td>+SA</td>
<td>100%</td>
<td>1.71e*±0.04</td>
<td>0.88d±0.02</td>
<td>3.61d±0.40</td>
<td>22.58±1.50</td>
<td>65.38d±0.69</td>
<td>50.05d±0.61</td>
</tr>
<tr>
<td>80%</td>
<td>2.50a*±0.04</td>
<td>1.81d±0.03</td>
<td>8.88d±0.27</td>
<td>36.23±0.36</td>
<td>105.0d±0.93</td>
<td>69.64d±0.78</td>
<td>69.64d±0.78</td>
</tr>
<tr>
<td>60%</td>
<td>2.23b*±0.05</td>
<td>1.87d±0.03</td>
<td>10.19d±0.11</td>
<td>36.07±0.67</td>
<td>103.7d±0.77</td>
<td>85.10d±0.66</td>
<td>85.10d±0.66</td>
</tr>
<tr>
<td>40%</td>
<td>2.13bc±0.06</td>
<td>1.69bc±0.01</td>
<td>8.58bc±0.22</td>
<td>31.15±0.69</td>
<td>90.89c±0.90</td>
<td>80.15bc±0.59</td>
<td>80.15bc±0.59</td>
</tr>
</tbody>
</table>

LSD (5%) 0.179 0.094 0.729 2.273 2.288 1.527 1.741

-ASC = Absence of ASC, Soaking Seeds in distilled water before germinated
+ASC= Presence of ASC, Soaking Seeds in Ascorbic Acid before germinated

Values are expressed as the mean of five samples ± Standard Deviation (=SD)

Statistical Analysis treatments, where relevant, the experimental data were subjected of One Way analysis of variance (ANOVA). Note: F values *= P > 0.05, ** = P > 0.01, *** = P > 0.001 and N.S. = Not Significant.


magnesium porous nanostructures

Xiangwen Chen


Xiangwen Chen; Yuping He; Yiping Zhao; Xinwei Wang (2009). Thermo physical properties of hydrogenated vanadium-doped
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