# Growth, Yield and Seed Quality of *Lupinus termis* as Affected by Different Soil Moisture Levels and Different Ways of Yeast Application

Soha E. khalil[1] and Ezzat G. Ismael[2]
[1]Department of Water Relation and Field Irrigation, National Research Center, Dokki, Cairo, Egypt
[2]Department of Medicinal and Aromatic Research, Horticulture Research Institute, Giza, Cairo, Egypt
soha_khalil2001@yahoo.com*

**Abstract:** Two pot experiments were carried out in the greenhouse of National Research Center. Dokki, Egypt during 2008 and 2009 seasons in order to investigate the effect of different soil moisture levels (75, 55 and 35% depletion of the available soil water) and yeast application (at rate of 8 g/L) by different ways (as a foliar, soil and foliar plus soil treatments) on growth, yield and seed quality of *Lupinus termis.* The results indicated that the highest growth parameters and RWC % observed when plants grown under the highest soil moisture level W3 and treated with yeast by foliar plus soil treatment followed by foliar treatment where the difference between the two treatments was insignificant. The number of seeds /plant, number of pods/plant and 100-seeds weight were decreased by increasing drought stress so as reached their maximum decease under the most stressed level W1, treated plants with yeast by different ways resulting in an increase in yield and yield attributes of lupinus plants. Also, both chla and chlb showed progressive increase by increasing soil moisture levels from W1 to W3, yeast application by different ways showed also progressive increase in chla and chlb. In addition, applied the highest level of soil moisture W3 combined with foliar application with yeast gave the highest significant values of nitrogen and protein percentages. Moreover, decreasing soil moisture levels caused significant increase in proline and alkaloids contents, treated plants with yeast by different ways induced significant decrease of proline and alkaloids content under different soil moisture levels. Furthermore, the highest records for carbohydrates percentage appeared in plants sprayed with yeast and grown under the highest soil moisture level W3. [Journal of American Science 2010;6(8):141-153]. (ISSN: 1545-1003).

**Keywords:** Growth; Yield and Seed Quality; *Lupinus termis;* Different Soil Moisture Levels; Yeast Application

## 1. Introduction

*Lupinus termis* is cultivated in a wide range of environments across Egypt. It's seed have a nutritional quality similar to soybean seed and superior to other legumes seed (Raza and Jrnsgard, 2005), and could be an important source of protein and oil. In fact, lupinus seeds have been used for human consumption and as a medicinal plant in Egypt (Kattab, 1986; ARC, 1994) and other countries for thousands of years.

The world is facing serious shortages of fresh water and growing competition for clear water, makes less water available for agriculture. The great challenge for the coming decades will be the task of increasing food production with less water, particularly in countries with limited water and land resources. Serious water shortages are developing in the arid and semi arid regions, as existing water resources are fully exploited (Jafar et al., 2007). To cope with the increasing food requirements and as drought is a major stress which adversely affects plant growth and productivity (Tawfik, 2008); it is important to develop stress tolerant crops (Mahajan and Tuteja, 2005). Improving tolerance of crop plats could be happened by different ways such using bio-stimulants which has been an important but largely unfulfilled aim of modern agricultural development (Gaballah and Gomaa, 2004). Bio-stimulants can be generally defined as some plant growth regulator or promoting substances such as vitamins, microelements, organic acids as well as preparations containing live cells (like bread yeast or Candida), which were microorganisms with the objective of increasing their number and of accelerating certain microbial process to increases the availability of nutrients elements in form which can be easily taken by plants. Thus greater attention has been directed on the use of microorganisms as bio-stimulants to provide nutrients for higher plants with out any pollution to the environment (Hayat, 2007). The objective of this work was mainly to investigate the response of growth, yield and seed quality of *lupinus termis* crop to different soil moisture levels and yeast application by different ways.

## 2. Material and Methods

An experiment was conducted during two winter seasons of 2008 and 2009 at the green house of the National Research Center, Dokki, Cairo, Egypt.

Treatments:

Water Treatments:

The following three water treatments were applied throughout the entire growth period of the crop:

W1= water stress maintained around 75% depletion of the available soil water and the soil water is maintained to field capacity when this depletion level is reached.

W2= water stress maintained around 55% depletion of the available soil water and the soil water is maintained to field capacity when this depletion level is reached.

W3= water level maintained around 35% depletion of the available soil water is maintained to field capacity when this depletion level is reached. The soil was sandy and it's physical and chemical analysis is shown in Table (1).

Yeast Application:

Yeast solution was prepared according to method described by Skoog and Miller (1957) at rate of 8g/L. The plants were treated with yeast in three different ways, the first was foliar application, and the second was soil application, while the third was foliar plus soil application. The plants were treated by these treatments two times during the crop life, the first application was after 45 days from planting and the second was two weeks later. The plants were sprayed until run off. The composition of yeast solution employed in the experiment was described in Table (2) as found by Nagodawithana (1991).

Planting and watering procedure:

Seeds of *Lupinus termis* (Var. Balady) provided from the Egyptian Agricultural Research Center and were thoroughly washed with distilled water and soaked for about six hours, then the seeds were directly planted in earthenware pots 40 diameter and 40 cm height with perforated bottoms, and were filed with 10 kg of sandy soil. Five seeds were planted in each pot and thinned down to two plants after emergency the number of plants per pot was determined on the basis of the area of the pot at a recommended seed rate $m^2$ (Soub, 1984). Each pot was maintained to water field capacity 19%, one day before starting the treatments, so that the soil moisture amount at each pot is uniform. All pots were weighted every 1 to 3 days on abeam balance. The pots were then irrigated to restore the soil to the appropriate moisture regime by adding a calculated amount of water. The general principal stated by Boutraa and Sanders (2001) was used for the water treatment application.

Design of the Experiments:

This experiment included 12 treatments which were the combination between three soil moisture levels (75, 55, 35% depletion of the available soil water) and four ways of yeast application (0, foliar, soil, foliar plus soil treatments), treatments were arranged in a split plot design with three replicates, different soil moisture levels were assigned at random in the main plots, while sub-plots were devoted to the different ways of yeast application.

Data Collection:

The following characters were either measured or computed on three lupinus plants:

Plant height (cm), number of leaves per plant, root length, fresh and dry weights of the whole plant, number of pods per plant, number of seeds per plant and 100 seeds weight were obtained. The photosynthetic pigments of fresh leaves, chlorophyll a and b were determined using for such purpose the 4th leaf from the growing point of the plant using the spectrophotometric method recommended by Metzener *et al.,* (1965). The relative water content percent was measured also on fresh leaves according to Weatherly (1962). Samples were collected and dried for 48 h at 70 °C to determine the total N in the dry tissue by the conventional micro kjeldabl method according to Bremner and Mulvaney (1982), then the protein (%) was also calculated using the equation of Alsmeyer *et al.*, (1974). Proline content was determined according to Troll (1995). Total soluble carbohydrates were determined according to Dubois et al., (1956). The total Alkaloids content of samples was assessed using a method described by Koriesh (1989).

Statistical analysis:

The collected data were subjected to statistical analysis of variance using the normal (F) test and the means separation were compared by using Least Significant Difference (LSD) at 5% level according to Snedecor and Cochran (1980).

## 3. Results and Discussion:

Growth Parameters:

Data presented in Tables 3 & 4 demonstrated the effect of different soil moisture levels and different ways of yeast application and their interaction on growth parameters of *Lupinus termis* plants, the data showed that increasing water stress from W3 to W1 caused significant decline in shoot length where the highest means for shoot length observed in plants grown under the highest water level W3 followed by the moderate water level W2 where the difference between to two levels was in significant, this result was true for both vegetative and flowering stages. Similar results were obtained by Mirsa and Srivastava (2000), Choi *et al.,* (2000), Ayodele (2001), Singh *et al.*, (2001) and villager and Cavagnaro (2006). Such decrease in shoot length in response to drought may either due to

**Table (1): Mechanical and chemical analyses of the tested soil.**

| Mechanical characteristics: | First season | Second season |
|---|---|---|
| Clay % | 18.00 | 16.00 |
| Sand % | 24.75 | 26.25 |
| Chemical Properties | | |
| PH | (1:2.5) 7.25 | 7.9 |
| E.C. | (1:5) 1.1dsm$^{-1}$ | 1.0 |
| Available macro nutrients (ppm) | | |
| Na | 3.42 | 5.0 |
| N | 189.10 | 170 |
| P | 3.14 | 4.98 |
| K | 259.75 | 244.25 |
| Ca | 65.15 | 55.21 |
| Mg | 73.18 | 65.22 |
| Available mirco nutrient (ppm) | | |
| Fe | 15.14 | 12.21 |
| Mn | 21.81 | 19.32 |
| Zn | 1.18 | 1.34 |
| Cu | 1.31 | 1.0 |
| Cl | 0.78 | 0.66 |

**Table (2): The composition of active yeast.**

| | | | |
|---|---|---|---|
| Protein | 47% | | |
| Carbohydrates | 33% | | |
| Minerals | 8% | | |
| Nucleic acids | 8% | | |
| Lipids | 4% | | |
| The composition of minerals | | | |
| Na | 0.12 mg/g | Cu | 8.00 μ/g |
| Ca | 0.75 mg/g | Se | 0.10 μ/g |
| Fe | 0.02 mg/g | Mn | 0.02 μ/g |
| Mg | 1.65 mg/g | Cr | 2.20 μ/g |
| K | 21.0 mg/g | Ni | 3.00 μ/g |
| P | 13.5 mg/g | Va | 0.04 μ/g |
| S | 13.5 mg/g | Mo | 0.40 μ/g |
| Zn | 0.17 mg/g | Sn | 3.00 μ/g |
| Si | 0.03 mg/g | Li | 0.17 μ/g |
| The composition of Vitamins | | | |
| Thiamine | 60 - 100 μ/g | | |
| Riboflavin | 35 - 50 μ/g | | |
| Niacin | 300 - 500 μ/g | | |
| Pyridoxine HCL | 28 μ/g | | |
| Pantorhenate | 70 μ/g | | |
| Biotin | 1.3 μ/g | | |
| Cholin | 40 μ/g | | |
| Folic acid Vit. B12 | 5 - 13 μ/g | | |
| Vit.B12 | 0.001μ/g | | |

decrease in cell elongation resulting from water shortage which led to decrease in each of cell turgor or cell volume and eventually cell growth (Boyer, 1988) and / or due to blocking up of xylem and phloem vessels thus hindering any translocation through (Abdalla and El-Khoshiban, 2007).

The obtained data also revealed that there was an inverse relationship between increasing drought and number of leaves/plant, where the highest records obtained under the highest soil moisture level W3 followed by the moderate soil moisture level W2 where the difference between the two levels was insignificant. This result was true for the vegetative and of flowering stages. Such decrease in number of leaves/plant with increasing stress levels detected by Sahid and Jurami (1998), Choi *et al.,* (2000), Ayodele (2001), Garg *et al.,* (2001), Singh *et al*., (2001), Koyro (2006), Martin and Stephens (2006) and Abdalla and El-Khoshiban (2007). The reduction in leaves number/plant due to water stress can be attributed to its direct effect on cell division which arose from reduction in nucleic acid synthesis and /or enhancement of its breakdown (Ashraf *et al.,* 1996). This also may be attributed to hormonal imbalance which arose from increased ABA and decreased in IAA levels in stressed plants (Xu *et al*., 2002).

Data presented in the same table revealed also significant increase in root length with increase in stress levels, where the highest significant increase in root length obtained in plants grown under the most stressed level W1, this result was gained in both studied stages. Similar results obtained by Prior *et al.,* (1997), Chiatante *et al.,* (2000), Syman (2006) and Abdalla and El-Khoshiban (2007). Such increase in root length in response to drought was attributed to either the increase in gibberellins and cytokinin content of the root in response to drought which in turn stimulates root cell division and elongation.

It was also clear from the obtained data that both fresh and dry weights were highly significant declined under the most stressed level W1 in both stages. The decline in fresh weight may be attributed to the decrease in water content of stressed plant cells and tissue which led to loose of their turgor and thus shrink (Boyer, 1988). The results reached by Saxena and Nutiyal (2001), Fu and Huang (2001) and Monti *et al.,* (2006) confirmed our data. The decrease in both fresh and dry weights of stressed shoots revealed the influence of water on stimulating and regulating the photosynthetic enzymes which thus influence both the dry matter production and fresh weights (Abdalla and El-Khoshiban, 2007). For the effect of different ways of yeast application, the data illustrated that almost all ways of yeast application caused significant increase in growth parameters of both stages compared with control plants with few exceptions in soil treatments which revealed sometimes insignificant increase. The data also revealed that the highest significant means in growth parameters appeared in plants treated with yeast by spraying or by spraying plus soil treatments where the difference between the two treatments was insignificant. While the lowest means observed under soil treatments. These results were gained in both vegetative and flowering stages. The positive response of yeast application is in harmony with many others as Ahmed *et al.*, (1998), Ali (2001), Gad (2001), Heikal (2005) and Hayat (2007). This increase in growth parameters as well as fresh and dry weights may be attributed to that yeast contains macro and micro nutrition, also it has growth regulators and vitamins or may be due to that yeast stimulates the plant to build up dry matters. Concerning the effect of interaction between soil moisture levels and different ways of yeast treatment the data showed that the highest significant means for growth parameters observed when plants grown under the highest soil moisture level W3 and treated with yeast by foliar plus soil treatment followed by foliar treatment where the difference between the two treatments was insignificant, except for root length where the highest significant increase obtained under the most stressed level W1 and treated with yeast by foliar plus soil treatment, these results were true for both vegetative and flowering stages.

**Table (3): Growth characters of *Lupinus termis* as affected by different soil moisture levels and different ways of yeast application at the vegetative stage (combined analysis of two seasons).**

| Characters / Treatments | | Plant height (cm) | No of leaves/ plant | Root length (cm) | Fresh weight/plant (g) | Dry weight/plant (g) |
|---|---|---|---|---|---|---|
| **Soil moisture levels** | | | | | | |
| **W1** | | 29.50 | 10.83 | 13.96 | 4.01 | 1.34 |
| **W2** | | 38.00 | 13.83 | 13.63 | 6.24 | 1.54 |
| **W3** | | 38.83 | 14.50 | 9.63 | 6.43 | 1.76 |
| **LSD0.05** | | 1.20 | 2.37 | 0.98 | 0.62 | 0.28 |
| **Ways of yeast application** | | | | | | |
| **Control** | | 32.11 | 10.44 | 11.17 | 4.66 | 1.35 |
| **Foliar** | | 37.44 | 13.78 | 13.39 | 5.98 | 1.68 |
| **Soil** | | 35.11 | 13.67 | 11.61 | 5.49 | 1.37 |
| **Foliar + Soil** | | 37.11 | 14.33 | 13.44 | 6.11 | 1.77 |
| **LSD0.05** | | 1.08 | 0.98 | 0.56 | 0.51 | 0.38 |
| **Soil moisture levels X Ways of yeast application** | | | | | | |
| **W1** | **Control** | 29.00 | 8.67 | 13.00 | 2.85 | 1.12 |
| | **Foliar** | 29.67 | 12.00 | 13.33 | 4.62 | 1.52 |
| | **Soil** | 29.00 | 10.67 | 14.50 | 3.76 | 1.13 |
| | **Foliar + Soil** | 30.33 | 12.00 | 15.00 | 4.82 | 1.58 |
| **W2** | **Control** | 33.67 | 10.00 | 12.83 | 5.08 | 1.75 |
| | **Foliar** | 41.00 | 15.33 | 13.17 | 6.54 | 1.86 |
| | **Soil** | 33.67 | 14.67 | 14.00 | 6.17 | 1.45 |
| | **Foliar + Soil** | 40.00 | 15.33 | 14.50 | 6.34 | 1.81 |
| **W3** | **Control** | 33.67 | 12.67 | 7.67 | 6.05 | 1.19 |
| | **Foliar** | 41.00 | 15.00 | 8.33 | 6.77 | 1.60 |
| | **Soil** | 39.00 | 14.67 | 11.17 | 6.54 | 1.53 |
| | **Foliar + Soil** | 41.67 | 15.67 | 11.33 | 7.16 | 1.99 |
| **LSD0.05** | | 2.01 | 1.26 | 1.01 | 0.98 | 0.66 |

W1 = 75% depletion of the available soil water. W2 = 55% depletion of the available soil water. W3 = 35% depletion of the available soil water.

**Table (4): Growth characters of *Lupinus termis* as affected by different soil moisture levels and different ways of yeast application at the flowering stage (combined analysis of two seasons).**

| Characters / Treatments | | Plant height (cm) | No of leaves/ plant | Root length (cm) | Fresh weight/plant (g) | Dry weight/plant (g) |
|---|---|---|---|---|---|---|
| **Soil moisture levels** | | | | | | |
| **W1** | | 40.08 | 9.17 | 18.83 | 4.48 | 1.12 |
| **W2** | | 59.08 | 23.67 | 16.00 | 8.12 | 1.74 |
| **W3** | | 60.83 | 24.33 | 12.33 | 11.08 | 2.70 |
| **LSD0.05** | | 2.63 | 1.02 | 2.23 | 0.93 | 0.21 |
| **Ways of yeast application** | | | | | | |
| **Control** | | 49.89 | 17.11 | 12.11 | 6.16 | 1.21 |
| **Foliar** | | 56.33 | 21.11 | 16.78 | 9.37 | 2.18 |
| **Soil** | | 50.56 | 17.44 | 16.22 | 9.06 | 1.68 |
| **Foliar + Soil** | | 56.56 | 20.56 | 17.78 | 9.98 | 2.35 |
| **LSD0.05** | | 1.19 | 0.89 | 1.39 | 0.82 | 0.11 |
| **Soil moisture levels X Ways of yeast application** | | | | | | |
| **W1** | **Control** | 37.33 | 8.33 | 14.33 | 3.41 | 0.62 |
| | **Foliar** | 42.00 | 10.00 | 19.00 | 5.25 | 1.36 |
| | **Soil** | 38.33 | 9..00 | 20.00 | 3.93 | 1.00 |
| | **Foliar + Soil** | 42.67 | 9.33 | 22.00 | 5.33 | 1.51 |
| **W2** | **Control** | 56.33 | 19.00 | 12.00 | 6.60 | 1.36 |
| | **Foliar** | 61.00 | 26.67 | 17.67 | 9.30 | 1.90 |
| | **Soil** | 57.00 | 21.33 | 16.00 | 7.01 | 1.72 |
| | **Foliar + Soil** | 62.00 | 24.00 | 18.00 | 9.58 | 2.00 |
| **W3** | **Control** | 55.00 | 22.67 | 10.00 | 8.46 | 1.66 |
| | **Foliar** | 65.00 | 27.33 | 13.00 | 12.57 | 3.20 |
| | **Soil** | 57.33 | 23.33 | 12.67 | 10.01 | 2.32 |
| | **Foliar + Soil** | 66.00 | 27.67 | 13.67 | 13.27 | 3.63 |
| **LSD0.05** | | 2.21 | 1.48 | 2.47 | 1.25 | 0.22 |

W1 = 75% depletion of the available soil water. W2 = 55% depletion of the available soil water. W3 = 35% depletion of the available soil water.

Relative water contents percent (RWC %):

Obtained data in Table 5 revealed that the RWC % of lupines leaves decreased progressively with decreasing soil moisture levels from W3 to W1 and with significant difference in both vegetative and flowering stages. Our results were confirmed with those obtained by Hayat et al., (1998), Toyagi *et al.,* (1999), Choi *et al.,* (2000), Flexas *et al.,* (2000), Phutela *et al.,* (2000), Garg *et al.,* (2001), Sanchez-Blance *et al.*, (2006) and Abdalla and Khoshiban (2007). The decline in RWC% with decrease in soil moisture level may be due to that stress causes modifications in plants metabolic pathway thus declining their osmotic and water potentials with concomitant preliminary decrease in their RWC % (Abdalla and Khashiban, 2007). Furthermore, treated plants with yeast by different ways caused significant increase in RWC% compared with control treatments in both stages, except for soil treatment of the flowering stage which revealed insignificant increase. The highest records for RWC% obtained in plants treated with foliar plus soil treatment followed by foliar treatment where the difference between the two treatments was insignificant at the flowering stage, while the lowest record obtained in soil treatment compared with control plants of the two stages. In addition, the data of interaction revealed that the highest significant means of RWC % obtained when plants grown under the highest soil moisture level W3 and treated with yeast by foliar plus soil treatment followed by foliar where the difference between the two treatments was insignificant at the flowering stage.

Yield and yield components:

Data in Table 6 revealed the effect of different soil moisture levels and different ways of yeast application on yield and yield components of *Lipinus termis*, the data indicated that the different soil moisture levels induced significant effect on number of pods/plant, number of seeds/ plant and 100 seeds weight. Also, the data indicated that there was a gradual decrease in all yield components with decrease in soil moisture level from W3 two W1. The reduction in yield and yield components of lupinus plant as a result of water stress was in harmony with that reported by Sepaskhan (1977), Elia and Mwandemele (1986), Osman (1989) and Hayat (2007). The reduction in yield components as result of water stress may attribute to reduction of leaf area, chlorophyll content and photosynthetic rate Jafar *et al*., (2007). Moreover, addition of adequate water decreased Absisic acid (ABA) and increased cytokinins (CYT) giberellin (GA) and indole acetic acid (IAA), which reflecting good plant growth, good carbohydrate anabolism and protein and finally attaining higher yield, it is known also that addition of water to plants has important functions in physiological processes such as minerals absorption from the soil, building different components in the plant, which in turn increase plants growth and yield (Hayat, 2007).

**Table (5): Relative water content % of *Lupinus termis* leaves as affected by different soil moisture levels and different ways of yeast application (combined analysis of two seasons).**

| Characters / Treatments | | Vegetative stage | Flowering stage |
|---|---|---|---|
| **Soil moisture levels** | | | |
| **W1** | | 28.52 | 30.38 |
| **W2** | | 41.39 | 53.24 |
| **W3** | | 53.48 | 60.95 |
| **LSD0.05** | | 3.40 | 3.15 |
| **Ways of yeast application** | | | |
| **Control** | | 36.79 | 44.64 |
| **Foliar** | | 41.74 | 50.78 |
| **Soil** | | 39.52 | 45.39 |
| **Foliar + Soil** | | 46.48 | 51.95 |
| **LSD0.05** | | 1.58 | 2.31 |
| **Soil moisture levels X Ways of yeast application** | | | |
| **W1** | **Control** | 25.09 | 27.65 |
| | **Foliar** | 29.60 | 30.95 |
| | **Soil** | 28.20 | 30.03 |
| | **Foliar + Soil** | 31.19 | 32.88 |
| **W2** | **Control** | 39.04 | 51.06 |
| | **Foliar** | 40.66 | 56.83 |
| | **Soil** | 40.35 | 50.54 |
| | **Foliar + Soil** | 45.52 | 54.51 |
| **W3** | **Control** | 46.23 | 55.22 |
| | **Foliar** | 54.96 | 64.55 |
| | **Soil** | 50.00 | 55.59 |
| | **Foliar + Soil** | 62.74 | 68.46 |
| **LSD0.05** | | 2.65 | 4.00 |

W1 = 75% depletion of the available soil water. W2 = 55% depletion of the available soil water. W3 = 35% depletion of the available soil water.

**Table (6): Yield and yield components of *Lupinus termis* as affected by different soil moisture levels and different ways of yeast application (combined analysis of two seasons).**

| Characters / Treatments | | No of pods/plant | No of seeds/plant | 100 seeds weight (g) |
|---|---|---|---|---|
| Soil moisture levels | | | | |
| **W1** | | 3.25 | 7.67 | 1.78 |
| **W2** | | 3.50 | 9.42 | 13.35 |
| **W3** | | 4.83 | 13.17 | 14.82 |
| **LSD0.05** | | 0.68 | 1.09 | 0.48 |
| **Ways of yeast application** | | | | |
| **Control** | | 3.00 | 7.67 | 8.40 |
| **Foliar** | | 4.22 | 11.44 | 10.68 |
| **Soil** | | 3.56 | 8.89 | 9.90 |
| **Foliar + Soil** | | 4.67 | 12.33 | 10.95 |
| **LSD0.05** | | 0.48 | 0.63 | 0.53 |
| **Soil moisture levels X Ways of yeast application** | | | | |
| **W1** | **Control** | 2.67 | 6.00 | 1.60 |
| | **Foliar** | 3.33 | 8.33 | 1.94 |
| | **Soil** | 3.00 | 7.00 | 1.67 |
| | **Foliar + Soil** | 4.00 | 9.33 | 1.91 |
| **W2** | **Control** | 2.67 | 6.33 | 10.74 |
| | **Foliar** | 4.00 | 11.33 | 14.76 |
| | **Soil** | 3.00 | 8.00 | 13.37 |
| | **Foliar + Soil** | 4.33 | 12.00 | 14.52 |
| **W3** | **Control** | 3.67 | 10.67 | 12.85 |
| | **Foliar** | 5.33 | 14.67 | 15.60 |
| | **Soil** | 4.67 | 11.67 | 14.65 |
| | **Foliar + Soil** | 5.67 | 15.67 | 16.16 |
| **LSD0.05** | | 0.82 | 1.09 | 0.82 |

W1 = 75% depletion of the available soil water. W2 = 55% depletion of the available soil water. W3 = 35% depletion of the available soil water.

Application of yeast by different ways induced significant increase in yield components, except for soil treatment of 100 seeds weight which reflect insignificant increase. The highest records of yield component obtained in foliar plus soil or foliar treatment where the difference between the two treatments was insignificant. The positive effect of yeast are in line with those obtained by Ahmed *et al*., (1998), Eid (2001), Gad (2001), Hend (2002) and Mekki and Amal (2005) whom reported that the increase in yield components as a result of yeast treatment mainly attributed to the effect of yeast which can play a very significant role in making available nutrient elements for plants, also yeast content macro and micro nutrients, growth regulators and vitamins or may due to that yeast stimulate the plant to build up dry matters (Heikal, 2005).

Regarding the data of interaction between different soil moisture levels and different ways of yeast application the obtained data illustrated that the maximum records obtained when plants grown under the highest soil moisture level W3 and treated with yeast by foliar plus soil or foliar treatments where the difference between two treatments was significant.

Photosynthetic pigments content:

The results presented in Table 7 showed that there was an inverse proportional relationship between increasing the severity of drought on one hand and content of leaves of chlorophyll a and b on the other hand where the highest means of chla and b obtained under the highest soil moisture level W3 and with significant difference, this result was true for both growth stages. Our result were fortified by those of Flexas *et al.*, (2000), El-Tayeb and Hassanien (2000), Misra and Srivastava (2000), Wang *et al.,* (2001), Sawhney and Singh (2002), Sanchez-Blanco *et al.,* (2006), Zhang *et al.,* (2006) and Abdalla and El-khoshiban (2007). Such reduction in the content of photosynthetic pigments in response to water stress was attributed to the ultra structural deformation of plastids including the protein membranes forming the thylakoids which in turn causes untying of photo system 2 which capture photons, so its efficiency declined, thus causing declines in electron transfer, ATP and NADPH production and eventually CO2 fixation processes (Maslenkova and Toncheva, 1997 and Zhang et al., 2006). Data in the same table revealed also that plants treated with yeast by different ways showed significant increase in chla and chlb compared with control plants in both stages. The data also showed that the highest records of chla and chlb obtained in foliar treatment of yeast and with significant difference compared with control treatment. While the lowest means obtained in soil treatment. The positive effect of yeast on chla and chlb is in harmony with that obtained by Hayat *et al.,* (2007) Stino *et al.,* (2009).

Concerning the interaction between different soil moisture levels and different ways of yeast application, the data of interaction showed significant effect on chla and chlb. Also both chla and chlb showed also progressive increase by increasing soil moisture levels from W1 to W3; it is also clear that chla and chlb showed progressive increase with yeast application by different ways under different soil moisture levels as compared with control treatments. Where the highest significant increase in chla and chlb obtained in foliar treatments of yeast and under the highest soil moisture level W3, while the lowest significant means obtained in untreated plants with yeast and under the most stressed level W1 followed by soil treatment.

Nitrogen and total protein %:

The data shown in Table 8 visualized that both nitrogen and protein % of lupinus seeds were significantly increased by increasing soil moisture level so as to reach their maximum records under the highest soil moisture level W3. These results were documented by many researches done in this field e.g Ahmed *et al.,* (1995), Hammam (1996), Yousef (1997), Neves and Lourenco (2001), Hayat (2007) and Bibi *et al.,* (2009) they all indicated that the increase in protein % may attributed to the slow hydrolysis of proteins under water stress conditions.

Application of active dry yeast by different ways resulted in significant increase in nitrogen and protein percentage as compared with control treatment. Where the maximum values obtained in plants sprayed with yeast (foliar application) compared with control treatment. These results are in harmony with those obtained by El-Kholy and Gomaa (2000), Schmid *et al.,* (2000), Ahmed (2002), Hassanein *et al.,* (2003), Gaballah and Gomaa (2004) and Hayat (2007). The increase in N and protein % could be attributed to the growth hormones produced by yeast (Gaballah and Gomaa, 2004) or may due to that yeast application stimulate the synthesis of protein (Stino, 2009). The interaction between different soil moisture levels and different ways of yeast application had significant effect on nitrogen and protein percentage. Applied the highest level of soil moisture W3 combined with foliar application with yeast gave the highest significant value of nitrogen and protein percentage. Similar results obtained by Hayat (2007) she indicated that the positive effect of yeast treatment under water stress conditions may be due to that yeast provided plants with essential nutrients elements required for protein formation.

Proline percent:

It is apparent from Table 8 that decreasing soil moisture levels from W3 to W1 showed significant increase in proline content of lupinus leaves so as to reach their maximum values in plants irrigated with the most stressed level W1. Accumulation of proline is an important indicator of drought stress tolerance in higher plants (Aspinall and Paleg, 1981). Karamanos et al., (1983) observed that increased amounts of free proline in two wheat cultivars could be associated with more effective dehydration and drought avoidance mechanisms.

Table (7): Chlorophyll content of *Lupinus termis* as affected by different soil moisture levels and different ways of yeast application (combined analysis of two seasons).

| Treatments \ Characters | | Vegetative stage | | Flowering stage | |
|---|---|---|---|---|---|
| | | **Chlorophyll a** | **Chlorophyll b** | **Chlorophyll a** | **Chlorophyll b** |
| **Soil moisture levels** | | | | | |
| **W1** | | 1.65 | 0.28 | 0.56 | 0.30 |
| **W2** | | 2.11 | 0.69 | 1.42 | 0.55 |
| **W3** | | 3.60 | 1.51 | 1.97 | 0.82 |
| **LSD0.05** | | 0.56 | 0.11 | 0.17 | 0.04 |
| **Ways of yeast application** | | | | | |
| **Control** | | 1.70 | 0.63 | 1.09 | 0.45 |
| **Foliar** | | 3.20 | 0.97 | 1.55 | 0.68 |
| **Soil** | | 2.05 | 0.77 | 1.22 | 0.52 |
| **Foliar + Soil** | | 2.88 | 0.94 | 1.41 | 0.57 |
| **LSD0.05** | | 0.21 | 0.06 | 0.16 | 0.07 |
| **Soil moisture levels X Ways of yeast application** | | | | | |
| **W1** | **Control** | 0.40 | 0.17 | 0.28 | 0.11 |
| | **Foliar** | 2.78 | 0.34 | 0.74 | 0.44 |
| | **Soil** | 0.68 | 0.23 | 0.49 | 0.23 |
| | **Foliar +Soil** | 2.76 | 0.39 | 0.73 | 0.41 |
| **W2** | **Control** | 1.83 | 0.58 | 1.22 | 0.47 |
| | **Foliar** | 2.57 | 0.76 | 1.70 | 0.67 |
| | **Soil** | 1.94 | 0.64 | 1.43 | 0.49 |
| | **Foliar + Soil** | 2.12 | 0.78 | 1.32 | 0.57 |
| **W3** | **Control** | 2.87 | 1.14 | 1.55 | 0.78 |
| | **Foliar** | 4.26 | 1.82 | 2.21 | 0.94 |
| | **Soil** | 3.53 | 1.44 | 1.95 | 0.84 |
| | **Foliar + Soil** | 3.74 | 1.65 | 2.18 | 0.72 |
| **LSD0.05** | | 0.37 | 0.11 | 0.25 | 0.12 |

W1 = 75% depletion of the available soil water. W2 = 55% depletion of the available soil water. W3 = 35% depletion of the available soil water.

A similar trend was obtained by Ashraf and Ibram (2005), Salma *et al.,* (2006), Ashraf and Foolad (2007) and Tawfik (2008) who found that osmoprotectants such as proline and glycine betaine were increased under drought stress. Production of osmolytes is general way to stabilize membranes and maintain protein conformations at low leaf water potentials, and osmolytes play major role in osmotic adjustment and also protect the cells (Pinhero *et al.,* 2001).

Application of yeast by different ways caused significant decrease in proline content of lupinus leaves as compared with control plant where the lowest means observed in foliar treatment followed by foliar plus soil treatment where the difference between the two treatments was insignificant, previous results were supported by Levitt (1980), Hasegawa *et al.,* (1986), Hathout (1996) and Gaballah and Gomaa (2004) whom reported that biofertilization of *faba bean* with Rhodotrula sp (yeast) resulted in decreasing leaves content of proline under stress conditions.

For the effect of interaction between the studied factors, the data showed that decreasing soil moisture levels caused significant increase in proline content, also treated plants with yeast by different ways induced significant decrease of proline content under different soil moisture levels Moreover, the lowest means in proline content obtained when plants sprayed (foliar application) with yeast and grown under the moderate and highest soil moisture levels (W2 and W3).

Alkaloids content:

It is clear from data in Table 8 that there was an inverse proportional relationship between increasing soil moisture levels on one hand and content of alkaloids of lupinus seeds on the other hand, where the highest significant increase in alkaloids content obtained under the most stressed level W1. Similar results obtained by kennedy and Bush (1985) who reported that N-acetytle alkaloid increased five times under stress conditions above control treatment, while N- acetylloline increased two times under stress conditions above control treatment. Also Beverly (1987) reported an increase in alkaloids of pearl millet as influenced by drought stress, also Hőft (1996) reported similar results. In addition, treated plants with yeast by different ways caused significant decrease in alkaloids content as compared with control treatment, the highest decrease obtained in foliar plus soil treatment. For the effect of interaction between the studied factors, the data revealed significant effect on alkaloids content of lupinus seeds, increasing soil moisture levels caused significant decrease in alkaloids content, while the different ways of yeast application caused decrease in alkaloids content under different soil moisture levels, the maximum records of alkaloids content obtained in untreated plants and grown under the lowest soil moisture level W1. While the lowest means obtained in plants treated with yeast by soil plus foliar addition and grown under the highest soil moisture level W3.

**Table (8): Nitrogen, protein and Carbohydrates percentages, as well as Alkaloids and Proline content of *Lupinus termis* as affected by different soil moisture levels and different ways of yeast application(combined analysis of two seasons).**

| Characters / Treatments | | N% | Total Protein % | Alkaloids (mg/g) | Proline (mg/100g) | Carbohydrates% |
|---|---|---|---|---|---|---|
| **Soil moisture levels** | | | | | | |
| **W1** | | 3.63 | 22.63 | 16.67 | 1.06 | 42.52 |
| **W2** | | 4.81 | 30.04 | 14.81 | 0.75 | 52.79 |
| **W3** | | 5.71 | 34.92 | 10.78 | 0.63 | 60.79 |
| **LSD0.05** | | 0.42 | 2.64 | 0.73 | 0.09 | 2.28 |
| **Ways of yeast application** | | | | | | |
| **Control** | | 4.01 | 25.09 | 16.30 | 0.99 | 46.65 |
| **Foliar** | | 5.47 | 33.20 | 15.91 | 0.69 | 59.69 |
| **Soil** | | 4.58 | 28.61 | 13.71 | 0.84 | 48.89 |
| **Foliar +Soil** | | 4.79 | 29.90 | 10.42 | 0.73 | 52.89 |
| **LSD0.05** | | 0.26 | 1.60 | 0.31 | 0.05 | 1.00 |
| **Soil moisture levels X Ways of yeast application** | | | | | | |
| **W1** | **Control** | 2.70 | 16.88 | 19.07 | 1.34 | 29.76 |
| | **Foliar** | 4.27 | 26.67 | 18.90 | 0.98 | 52.22 |
| | **Soil** | 3.91 | 24.44 | 17.67 | 1.04 | 43.62 |
| | **Foliar + Soil** | 3.62 | 22.54 | 11.03 | 0.87 | 44.47 |
| **W2** | **Control** | 4.27 | 26.67 | 16.87 | 0.89 | 50.64 |
| | **Foliar** | 5.48 | 34.25 | 16.43 | 0.54 | 59.32 |
| | **Soil** | 4.43 | 27.71 | 15.20 | 0.84 | 48.08 |
| | **Foliar + Soil** | 5.05 | 31.54 | 10.73 | 0.74 | 53.12 |
| **W3** | **Control** | 5.08 | 31.73 | 12.97 | 0.73 | 59.55 |
| | **Foliar** | 6.67 | 38.67 | 12.40 | 0.54 | 67.54 |
| | **Soil** | 5.39 | 33.67 | 9.50 | 0.65 | 54.98 |
| | **Foliar + Soil** | 5.70 | 35.63 | 8.26 | 0.59 | 61.07 |
| **LSD0.05** | | 1.23 | 2.88 | 0.54 | 0.09 | 1.56 |

W1 = 75% depletion of the available soil water. W2 = 55% depletion of the available soil water. W3 = 35% depletion of the available soil water.

Total carbohydrates %:

It is evident from Table 8 that the values of total carbohydrates of lupinus seeds were significantly increased with increasing soil moisture levels from W1 to W3 and reached their maximum values under the highest soil moisture level W3. Our results were shown to be similar to those of Wang and Quebedeaux (1997), Osman (2000). Martinez *et al.,* (2004), Wu and Xia (2006), Abdalla and El-Khoshiban (2007) and Hayat (2007). We attributed the above decline in total carbohydrates percentages with decline in soil moisture to its bad effect on certain chemical stimulus mostly

ABA through xylem vessels to leaves and seeds of stressed plants which led to stomata closure, reduction of each of stomata conductance, CO2 concentration in leaf tissues, electron transport system, CO2 fixation, rate of photosynthesis and eventually quantity of photosynthates, thus causing decline in growth rates. Or it may be attributed to the decrease in chlorophyll content under stress conditions.

Furthermore, treated plants with yeast by different ways caused significant increase in total carbohydrates percentage compared with control treatment, where the highest significant increase in carbohydrates percentage obtained in plants sprayed (foliar spray) with yeast. While the lowest means obtained in plants treated with yeast in soil. The positive effect of yeast obtained also by Bahr and Gomaa, (2002), Gaballah and Gomaa (2004), Heikal (2005) and Hayat (2007). The increase in total carbohydrates % as a result of yeast application in our search may be due to the increases in chlorophyll a and b or may be due to that yeast application had enhancing role in cell division, cell elongation producing more leaf area (Hayat, 2007).

The data of bi-interaction indicates that the highest records of carbohydrates percentage appeared in plants sprayed with yeast and grown under the highest soil moisture level W3 as compared with other treatments, while the lowest values obtained under the most stressed levels W1 in control plants.

**Corresponding author**
Soha E. khalil
Department of Water Relation and Field Irrigation, National Research Center, Dokki, Cairo, Egypt
soha_khalil2001@yahoo.com

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