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# Response of Imbibing lettuce (*Lactuca sativa* var. *longifolia*)cv. Marul Seeds to Boron levels and mulching on head folding, bitterness and quality of produced seeds

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**Abstract**

The objective of this study was to reduce unfolding, bitterness and tip burns through adopting a new screening method to produce lettuce seeds and head yields of high qualities, to achieve these goals lettuce seeds and plant raised from them were treated with Boron and grown on bare and black polyethylene mulched soil at rates of 0, 25, 50 and 75mg.l$^{-1}$. Lettuce plants grown on bare soil profoundly exceeded that grown on black polyethylene mulched soils in head fresh weight by (20.3%), head yield (20.65%), folded leaves number (25.1%), stem length (78.98%), branches number after chopping (11.32%) and leaves number on stem (42.94%).Lettuce plant treated with 50mg.l$^{-1}$B profoundly exceeded untreated plants in stem length, T.S.S of folded leaves, stem and folded leaf base by (29.33, 35.36, 42.96 and 23.2%) respectively. The rate 50mg.l$^{-1}$B highly exceeded 75mg.l$^{-1}$B in stem length, T.S.S of stem and folded leaf base by (20.66, 25.84, and 15.18%) respectively, It also surpassed the other treatment in stem diameter (32.26, 23.87, and 20.94%), respectively. The rate 25 mg.l$^{-1}$ B treatment showed superiority over other treatments, since it highly exceeded untreated and 50 mg.l$^{-1}$ B in seeds yield.plant$^{-1}$ and seed yield.m$^{-2}$ by (53.63%). Moreover, it highly exceeded profoundly 75 mg.l$^{-1}$ B in seeds yield.plant$^{-1}$ and seed yield.m$^{-2}$ by (166.98%). Lettuce plants treated with 75mg.l$^{-1}$ and grown on bare soils was the best dual interaction as compared to other. It showed the highest values or very close to the highest ones in head fresh weight, head yield.m$^{-2}$, number of folded leaves, weight of folded leaves, TSS of folded leaves and branches height by (750g, 4.5Kg, 41.25, 440g, 6.8% and 54cm) respectively. Lettuce plants treated with 75mg.l$^{-1}$ B, grown on bare soils was the best dual interaction compared to others.

## Introduction:

Lettuce (*Lactuca sativa* L.) native belongs to the largest dicotyledonous family in the plant kingdom, the *Asteraceae (Compositae)*. The *Compositae* is the largest and most diverse of angiosperm families, comprising one-tenth of all flowering species *[1]*. Lettuce leaves are used principally as a raw product in salads. Lettuce is harvested and marketed in two main ways, firstly as whole lettuce plants cut and used as desired by the consumer. Secondly, as a more convenient ready cut, washed and pre- packaged product *[2]*. Significant and exciting changes have taken place in the world of fresh produce in the past thirty years. It is not unlikely that these changes continued extending the evolutionary story began several thousand years ago *[3]*.

The United States is the second largest lettuce producing country after China, which continues to dominate world production. U.S. production of lettuce in 2010 totaled 8.7 billion pounds *[4]* .A large portion of China's production is consumed domestically, however, making Chinese exports less than U.S. exports worldwide Head lettuce is grown on almost two-thirds of the total acreage and continues to dominate total acreage percentages since the 1960s fluctuating from 198,000 to 256,000, but has decreased in the last 6 years, reaching as low as 182,000 acres in 2003. Conversely, acreage of romaine and leaf lettuce has been increasing in recent years *[5]*.

Plastic film mulching (FM) is one of the commonly used agricultural practices worldwide in crop production. It profoundly alters soil hydrothermal properties and processes such as conserving soil moisture, modifying soil chemical and physical environment, and affecting the forms of the elements. Soil nitrogen plays an important role in providing necessary nutrients for crops and thus enhancing crop productivity.

The role of boron (B) as a structural element of plant cell walls and its implications for plant growth has been well established. However, increasing evidence suggests one or more functions of boron beyond cell-wall structure *[6]*.

Lettuce plants that are in the early stages of bolting are visibly indistinguishable from non-bolting plants, however there are changes in the production of secondary metabolites such as sesquiterpene lactones and phenolic compounds, including lactucin, deoxylactucin and lactucopicrin *[7]* which are produced to protect the young floral bud from insect attack. These compounds give the plant a bitter taste which renders the crop unsaleable *[2; 8; 9]*.

Seed thermo inhibition and photodormancy are two properties commonly affecting germination speed *[10]*. Several methods exist to overcome seed dormancy, such as primed seeds, stratification or chilling, scarification, and various chemical compounds (e.g. gibberellic acid, $KNO_3$) *[11;12]*. The main limiting factor to lettuce production in the Southeast is bitterness. Bitterness in lettuce is associated with sesquiterpene lactones, a bitter principle of the latex of wild lettuce species *Lactuca virosa* or *L. sativa [13]*.

The objective of this study was to produce head yield of lettuce and lettuce seeds of high quality capable of giving low tip burn incidences, devoid of bitterness and higher heading percentages under rainfall incidences of Sulaimani district, Kurdistan region, Iraq.

## Materials and Methods:

### A. *Experiments location:*

In this investigation, during lettuce growing season of 2012 at Bakrajo research field, Horticulture Department, College of Agricultural Sciences, University of Sulaimani, Kurdistan Region, Iraq. The field is located on Latitude (35°, 32.134' N) Altitude (732 m) and Longitude (45°, 21.879'E).

Lettuces (*Lactuca sativa* L. Var. Longifolia) Marul was evaluated for lowest bitterness, unfolded and physiological disorders incidences. Seeds were purchased from Agricultural Bureau, Sulaimani where Marul seeds produced by the Turkish/Argeto Company for vegetable seed production, Turkey, under lot number TR7913120AY, germination percentage 83%, tested on August, 2009 and seed purity 99%.

### B. *Experimental design and statistical analysis:*

Split Plot within Factorial Randomized Complete Block Design (Split F-RCBD) was applied, where the main plots (A) consisted of: bare soil ($a_1$) and soil mulched with black polyethylene ($a_2$). Whereas, the sub plots (B) were Boron rates 0 ($b_1$), 25mg.$l^{-1}$ ($b_2$), 50 mg.$l^{-1}$ ($b_3$) and 75mg.$l^{-1}$ ($b_4$) each treatment contained four replicates. Each replicate represented by 4 furrows.

The treatments were analyzed by S.P.S.S. Statistical analysis and the means for all experiments were compared with Duncan's multiple range tests at 0.05 level *[14]*.

### *C. Cultural practices:*

Lettuce seeds imbibed in distilled water at 5°C for 48hrs, then germinated in Petri dishes equipped with moistened filter paper, germinated seeds were translocated to seed trays. Lettuce transplants of 4-5g with 4-6 leaves about 6-8 cm then transplants were planted on October, 1st 2011 in a permanent field on bare soil and black polyethylene.

The plants were sprayed twice on January 1 as well as February, 1 of the same year.

Soil was plowed twice horizontally and then vertically followed with phosphorus $P_2O_5$ fertilizer application broadcasted at rate of 10g.m$^{-2}$ then soil was harrowed and thereafter dissected to match the experimental design, half of experiments area was left bare while the other half was covered with black polyethylene where the polyethylene edge was covered with soil to fix it. Slice of 20 cm length was made by cutter in the bottom of furrow covered with soil to ease rainfall and irrigation water penetration to the root zone.

Lettuce plants were matured on March, 25 2012. Well performed heads were chopped at 5cm above the soil surface and left for seed stalk formation to collect their seeds at the end of the growing season. The stump of chopped plants were fertilized and watered to burst new shoots and flowers to produce the collected seeds. Unfolded and poor performed heads were pulled out of soil and disposed to avoid pollination with the flowers of desired plants proposed for seed production. Finally, harvested plants were enclosed in polyethylene bags and brought to the laboratory for further measurements.

Inflorescences were harvested once they completely dried and preserved in open polyethylene bags thereafter seeds were obtained from inflorescence cleaned and later on the parameters were recorded.

Vegetative growth and reproductive parameters, Total Soluble Solids and Chlorophyll, Tipburn evaluation, Organoleptic evaluation for bitterness, Total Nitrogen determination and Boron determination, Measurements were carried out in laboratories of Agricultural Sciences, Sulaimani Univ., while Plant nutrient analysis was carried out in the laboratories of the College of Agriculture and Forestry, Duhok Uni.

### *D. Measurements*

*Vegetative growth and reproductive parameters:*

Stem length (cm), stem diameter at chopped places (cm) and branches length (cm) were measured by ruler and caliper. Unfolded leaves, folded leaves, branches number of chopped heads, number of leaves on formed branches and branches number of inflorescence were counted. Head fresh weight (g), yield of head fresh weight.m$^{-2}$ (kg) fresh weight of folded leaves (g), the weight of unfolded leaf bases (g), fresh weight of unfolded leaves (g), seed yield.m$^{-2}$ (g), seed yield .plant$^{-1}$ (g) and weight of 1000 seeds (g) were weighed by four decimal electrical balances. Folded leaves, unfolded leaves and stems, stem and leaf bases were weighed and then oven dried at 55°C for 48 hrs. Then re-weight to calculate their dry matter percentages.

*Total Soluble Solids T.S.S%:*

Total Soluble Solids of folded leaves, unfolded leaves, stem and the base of folded leaves were measured by Hand Refractometer (ATAGO PAL 1 -Japan).

*Tipburn evaluation*:

After observation of the heads and assuring that they were free from death of leaf tissues and along the leaf margins in the interior leaves of the heads they were marked as there were no tip burns.

*Organoleptic evaluation for bitterness:*

The lettuce heads were given to 50 of the teaching staff of the Horticulture Department, College of Agricultural Sciences -University of Sulaimani and randomly determined as a sensory evaluation panel. Each member of the panel has filled a sensory evaluation chart, and recorded.

*Plant nutrient analysis:*

Iron, copper and calcium were determined by Atomic Absorption Spectrophotometer. Sodium and potassium were determined by Flame Photometer *[15]*.

*Total Nitrogen determination:*

Nitrogen percentages were determined according to Kjeldahl method *[15]*.

*Boron determination:*

Boron in plant samples was determined by dry ashing *[15]* and subsequently by colorimeter using Azomethine-H *[16]*, with the aid of Spectrophotometer, 420-nm wavelength (Shimdzu, Japan).

*Superiority percentages:*

Superiority percentages were calculated in comparing the exceeded values as below *[17]*:

$$\% \text{ Superiority} = \frac{\text{Maximum number} - \text{Minimum number}}{\text{Minimum number}} \times 100$$

## Results and Discussion:

***A. Lettuce vegetative growth parameters and T.S.S% responses to boron levels and mulching:***

***Lettuce vegetative growth parameters responses to boron levels and mulching:***

The table (1) showed the influence of Boron levels ($mg.l^{-1}$) and mulching on vegetative growth parameters and T.S.S%. The data revealed that lettuce plants grown on bare soil profoundly exceeded that grown on black polyethylene mulched soils in head fresh weight (20.3%), head yield (20.65%), folded leaves number (25.1%), stem length (78.98%), branches number after chopping (11.32%), leaves number on stem (42.94%), dry matter of unfolded leaves (16.02%).

The data revealed that lettuce plant treated with $50mg.l^{-1}B$ profoundly bypassed $25mg.l^{-1}B$ in branch number after chopping by (19.44%). $50mg.l^{-1}B$ highly exceeded the other treatment in stem diameter (32.26, 23.87, and 20.94)% respectively. Lettuce plant treated with $75mg.l^{-1}B$ showed higher superiority over untreated plants in stem diameter and dry matter % of unfolded leaves by (32.26 and 8.54)%, respectively. This treatment also bypassed $25mg.l^{-1}$ B in stem diameter, branch number after chopping and dry matter % of unfolded leaves by (23.87, 19.29 and 22.17)%, respectively. Lettuce plants treated with $25mg.l^{-1}B$ showed superiority over control and $50mg.l^{-1}B$ treatment in branch length, leaves number on stem and floret branch number (27.22, 50.64 and 41.86)% and also superior over $50mg.l^{-1}B$ treatment in the same characters by (45.38,49.1 and 50.54)% respectively. This treatment profoundly surpassed $75mg.l^{-1}B$ in branch length, leaves number on stem and floret branch number (16.84 34.96 and 35.56)% respectively. Whereas, control plants showed superiority over other treatments only in branch number after chopping by (32.2, 10.68 and 10.82)%, respectively. This treatment bypasses $50mg.l^{-1}$ B in branch length by (14.27%).

*Lettuce T.S.S% responses to boron levels and mulching:*

Table (2) showed the influence of Boron levels ($mg.l^{-1}$) and mulching on T.S.S%. The data revealed that lettuce plant treated with $50mg.l^{-1}B$ profoundly exceeded untreated plants in T.S.S of folded leaves, stem and folded leaf bases by (35.36, 42.96 and 23.2)%, respectively. This treatment bypassed $25mg.l^{-1}B$ in T.S.S of folded leaves, stem and folded leaf bases (20.46, 21.26 and 29.89)%, respectively. $50mg.l^{-1}B$ highly exceeded $75mg.l^{-1}B$ in T.S.S of stem and folded leaf bases by (25.84, and 15.18)%, respectively. Lettuce plant treated with $75mg.l^{-1}B$ showed higher superiority over untreated plants in stem diameter, dry matter % of unfolded leaves and T.S.S of folded leaves by (41.65%). This treatment also bypassed $25mg.l^{-1}$ B in T.S.S in folded leaves (26.06)%.

Table -1: The influence of Boron levels (mg.l$^{-1}$) and mulching on vegetative growth parameters

| ***B (mg.l$^{-1}$)*** | ***Data superiority%*** | | | | |
|---|---|---|---|---|---|
| ***The exceeded treatments*** | ***Head fresh weight (g)*** | ***Yield.m$^{-2}$ (kg)*** | ***Folded leaves no.*** | ***Stem length (cm)*** | ***Stem diameter (cm)*** |
| ***Bare soil/ Mulching*** | *20.30* | *20.65* | *25.10* | *78.98* | *N.S* |
| ***75/0*** | *N.S* | *N.S* | *N.S* | *N.S* | *32.26* |
| ***75/25*** | *N.S* | *N.S* | *N.S* | *N.S* | *23.87* |
| ***75/50*** | *N.S* | *N.S* | *N.S* | *N.S* | *20.94* |
| | ***Branch number after chopping*** | ***Average Branch length (cm)*** | ***Leaves number on stem*** | ***Floret branch no.*** | ***Dry matter % of unfolded leaves*** |
| ***Bare soil/ Mulching*** | *11.32* | *N.S* | *42.94* | *N.S* | *16.02* |
| ***Mulching/Bare soil*** | *N.S* | *N.S* | *N.S* | *167.86* | *N.S* |
| ***0/25*** | *32.20* | *N.S* | *N.S* | *N.S* | *N.S* |
| ***0/50*** | *10.68* | *14.27* | *N.S* | *N.S* | *N.S* |
| ***0/75*** | *10.82* | *N.S* | *N.S* | *N.S* | *N.S* |
| ***25/0*** | *N.S* | *27.22* | *50.64* | *41.86* | *N.S* |
| ***25/50*** | *N.S* | *45.38* | *49.10* | *50.54* | *N.S* |
| ***25/75*** | *N.S* | *16.84* | *34.96* | *35.56* | *N.S* |
| ***50/25*** | *19.44* | *N.S* | *N.S* | *N.S* | *N.S* |
| ***75/0*** | *N.S* | *N.S* | *N.S* | *N.S* | *8.54* |
| ***75/25*** | *19.29* | *N.S* | *N.S* | *N.S* | *22.17* |
| ***75/50*** | *N.S* | *24.43* | *N.S* | *N.S* | *22.17* |

N.S Denote that there is no superiority

Table -2: The influence of Boron levels (mg.l$^{-1}$) and mulching on T.S.S%

| ***B (mg.l$^{-1}$)*** | ***T.S.S%*** | | |
|---|---|---|---|
| ***The exceeded treatments*** | ***folded leaves*** | ***stem*** | ***folded leaf bases*** |
| ***50/0*** | *35.36* | *42.96* | *23.20* |
| ***50/25*** | *20.46* | *21.26* | *29.89* |
| ***50/75*** | *N.S* | *25.84* | *15.18* |
| ***75/0*** | *41.65* | *N.S* | *N.S* |
| ***75/25*** | *26.06* | *N.S* | *N.S* |

N.S Denote that there is no superiority

***B. Lettuce leaf parts mineral content responses to boron levels and mulching:***

Table (3) showed the influence of Boron levels (mg.l$^{-1}$) and mulching on leaf parts mineral content. Lettuce plants grown on bare soil profoundly exceeded that grown on black polyethylene mulched soils in K content of unfolded leaves (15.57%), Fe content of folded leaves and folded leaf bases (40.59 and 28.03)% respectively.

Data revealed that Mulching treatment manifested superiority over bare soils in B content of folded leaf bases (38.84%), N content of folded leaves, unfolded leaves and stem (7.96, 16.5 and10.03)% respectively, K content of folded leaves, stem and folded leaf bases (66.82, 44.57 and 33.63)% respectively, Fe content of unfolded leaves (40.5%), Cu content of folded, unfolded leaves, stem and folded leaf bases were (920.83, 115.74, 921.59 and 880.5)% respectively and Ca content of folded leaves, stem and folded leaf bases were (83.18, 45.97 and 28.49)% respectively. Black polyethylene mulch appeared to exert adverse negative influences on plant growth and thus, it was over ridden by bare soil owing to the high temperature that have been imposed at the early fall season which obviously reflected on the root growth performance besides its mineral uptake capabilities. Temperatures as high as (58 °C) have been recorded in containers in southern states[18];[19]Normal root functioning ceases when root zone temperatures exceed (36 °C) for Holly [20] and at even lower, approximately (32 °C) for less heat tolerant plants [21]. Media above 138 °F (59 °C) are also reached in Ohio in the center of one-gallon containers on gravel beds. In above ground containers, roots in the western quadrant of the container are often injured or killed by high temperatures. In Pot-In-Pot (PIP) systems, root temperature in the western quadrant were 23 °F (12.8 °C) cooler than in above ground pots [22].

75 $mg.l^{-1}$ B profoundly exceeded untreated control in N content of folded leaf bases (15.51%), Fe content of folded leaf and stem (50.46 and 50.94%) and Cu content of folded leaves and folded leaf bases were (301.37 and 192.92)% respectively. This rate profoundly exceeded 25 $mg.l^{-1}$ B treatment in B content of folded leaves (97.96%), in N content of stem and folded leaf bases (43.83 and 68.27)% respectively, Fe content of folded leaves and stem (11. 22 and 36.57)% respectively. 75 $mg.l^{-1}$ B showed superiority over 50 $mg.l^{-1}$ B in N content of folded leaf bases (144.76%), Fe content of folded leaves and stem (12.9 and 68.27)% respectively, and Cu content of unfolded leaves by 110.97%. 25 $mg.l^{-1}$ B treatments exceeded untreated in N content of folded leaves and unfolded leaves (6.24 and 19.62)% respectively, K content of folded leaves (84.43%), Na content of unfolded leaves (73.39%), Fe content of stem (10.52%) and Cu content of folded leaves, unfolded, stem and folded leaf bases were (312.91,55.24,161.93 and2316.29)% respectively. This treatment highly exceeded 50 $mg.l^{-1}$ B in B content of stem (9.84%), N content of unfolded leaves (11.18%), K content of folded leaves (29.68%), Na content of unfolded leaves (64.12%), Fe content of stem (23.21%), Cu content of unfolded leaf and folded leaf base(223.5 and 628.59)% respectively, and Ca content of stem and folded leaf bases (79.22 and 117.52)% respectively. 25 $mg.l^{-1}$ B substantially surpassed 75 $mg.l^{-1}$ B in B content of stem (29.01%), N content of folded and unfolded leaves(2.07 and 23.13)% respectively, K content of folded leaves (98.36%), Na content of unfolded leaves (45.27%), Cu content of unfolded leaves, stem and folded leaf bases were (53.34,1 56.34 and 724.91) % respectively, Ca content of folded leaves, stem and folded leaf bases were (55.31, 62.95 and 100.06)% respectively.

Table -3: The influence of Boron levels (mg.$l^{-1}$) and mulching on leaf parts mineral content.

| ***B (mg.$l^{-1}$)*** | ***Data superiority%*** | | | |
|---|---|---|---|---|
| ***The exceeded treatments*** | ***B mg.$l^{-1}$ content*** | | | |
| | ***folded leaves*** | ***unfolded leaves*** | ***stem*** | ***folded leaf bases*** |
| ***Mulching/Bare soil*** | *38.84* | *N.S* | *N.S* | *N.S* |
| ***0/25*** | *128.63* | *58.26* | *N.S* | *N.S* |
| ***0/50*** | *N.S* | *13.68* | *4.56* | *N.S* |
| ***0/75*** | *N.S* | *27.31* | *22.81* | *N.S* |
| ***25/50*** | *N.S* | *N.S* | *N.S* | *9.84* |
| ***25/75*** | *N.S* | *N.S* | *N.S* | *29.01* |
| ***50/25*** | *115.34* | *N.S* | *N.S* | *N.S* |
| ***75/25*** | *97.96* | *N.S* | *N.S* | *N.S* |
| | ***N% content*** | | | |
| | ***folded leaves*** | ***unfolded leaves*** | ***stem*** | ***folded leaf bases*** |
| ***Mulching/Bare soil*** | *7.96* | *16.50* | *10.03* | *N.S* |
| ***25/0*** | *6.24* | *19.62* | *N.S* | *N.S* |
| ***25/50*** | *N.S* | *11.18* | *N.S* | *N.S* |
| ***25/75*** | *2.07* | *23.13* | *N.S* | *N.S* |
| ***50/0*** | *5.81* | *N.S* | *N.S* | *N.S* |
| ***50/25*** | *N.S* | *N.S* | *36.17* | *N.S* |
| ***50/75*** | *1.65* | *N.S* | *N.S* | *N.S* |
| ***75/0*** | *N.S* | *N.S* | *N.S* | *15.51* |
| ***75/25*** | *N.S* | *N.S* | *43.83* | *68.27* |
| ***75/50*** | *N.S* | *N.S* | *N.S* | *144.76* |
| ***0/25*** | *N.S* | *N.S* | *108.51* | *N.S* |
| ***0/50*** | *N.S* | *N.S* | *53.13* | *N.S* |
| ***0/75*** | *N.S* | *N.S* | *44.97* | *N.S* |
| | ***K mg.$l^{-1}$ content*** | | | |
| | ***folded leaves*** | ***unfolded leaves*** | ***stem*** | ***folded leaf bases*** |
| ***Mulching/Bare soil*** | *66.82* | *N.S* | *44.57* | *33.63* |
| ***Bare soil/Mulching*** | *N.S* | *15.57* | *N.S* | *N.S* |
| ***0/25*** | *N.S* | *72.57* | *31.21* | *61.43* |
| ***0/50*** | *N.S* | *N.S* | *35.70* | *83.52* |
| ***0/75*** | *N.S* | *47.17* | *25.07* | *68.18* |
| ***25/0*** | *84.43* | *N.S* | *N.S* | *N.S* |
| ***25/50*** | *29.68* | *N.S* | *N.S* | *N.S* |
| ***25/75*** | *98.36* | *N.S* | *N.S* | *N.S* |
| ***50/0*** | *42.21* | *N.S* | *N.S* | *N.S* |

| | | | | |
|---|---|---|---|---|
| *50/25* | *N.S* | *60.48* | *N.S* | *N.S* |
| *50/75* | *52.96* | *36.86* | *N.S* | *N.S* |
| | ***Na mg.l$^{-1}$ content*** | | | |
| | ***unfolded leaves*** | | | |
| ***25/0*** | *73.39* | | | |
| ***25/50*** | *64.12* | | | |
| ***25/75*** | *45.27* | | | |
| | ***Fe g.kg$^{-1}$ dry weight content*** | | | |
| | ***folded leaves*** | ***unfolded leaves*** | ***stem*** | ***folded leaf bases*** |
| ***Bare soil/Mulching*** | *40.59* | *N.S* | *50.94* | *28.03* |
| ***Mulching/Bare soil*** | *N.S* | *40.50* | *N.S* | *N.S* |
| ***75/0*** | *5046* | *N.S* | *36.57* | *N.S* |
| ***75/25*** | *11.22* | *N.S* | *68.27* | *N.S* |
| ***75/50*** | *12.90* | *N.S* | *N.S* | *N.S* |
| ***50/0*** | *N.S* | *N.S* | *N.S* | *41.83* |
| ***50/25*** | *N.S* | *N.S* | *N.S* | *32.36* |
| ***50/75*** | *N.S* | *N.S* | *N.S* | *32.82* |
| ***25/0*** | *10.52* | *N.S* | *N.S* | *N.S* |
| ***25/50*** | *23.21* | *N.S* | *N.S* | *N.S* |
| | ***Cu g.kg$^{-1}$ dry weight content*** | | | |
| | ***folded leaves*** | ***unfolded leaves*** | ***stem*** | ***folded leaf bases*** |
| ***Mulching/Bare soil*** | *920.83* | *115.74* | *921.59* | *880.5* |
| ***50/0*** | *3050.23* | *N.S* | *2582.11* | *231.64* |
| ***50/25*** | *662.94* | *N.S* | *923.99* | *N.S* |
| ***50/75*** | *684.87* | *N.S* | *2524.92* | *N.S* |
| ***25/0*** | *312.91* | *55.24* | *161.93* | *2316.29* |
| ***25/50*** | *N.S* | *223.5* | *N.S* | *628.59* |
| ***25/75*** | *N.S* | *53.34* | *156.34* | *724.91* |
| ***75/50*** | *N.S* | *110.97* | *N.S* | *N.S* |
| ***75/0*** | *301.37* | *N.S* | *N.S* | *192.92* |
| ***0/50*** | *N.S* | *108.39* | *N.S* | *N.S* |

| | | | |
|---|---|---|---|
| | ***Ca g.kg$^{-1}$ dry weight content*** | | |
| | ***folded leaves*** | ***stem*** | ***folded leaf bases*** |
| ***Mulching/Bare soil*** | *83.18* | *45.97* | *28.49* |
| ***0/50*** | *N.S* | *63.60* | *134.85* |
| ***0/75*** | *53.88* | *48.75* | *116.27* |
| ***25/50*** | *N.S* | *79.22* | *117.25* |
| ***25/75*** | *55.31* | *62.95* | *100.06* |
| ***50/75*** | *80.55* | *N.S* | *N.S* |

N.S Denote that there is no superiority

50mg.l$^{-1}$ B substantially bypassed untreated check in N content of folded leaves (5.81%), K content of folded leaves (42.21%) and Fe content of folded leaf bases (41.83%) and Cu content of folded leaves, stem and folded leaf bases were (3050.23, 2582.11 and 231.64)% respectively . This treatment highly exceeded that of 25 mg.l$^{-1}$ B in terms B content of folded leaves (115.34%), N content of stem (36.17%), K content of unfolded leaves (60.48%) ,Fe content of folded leaf bases (32.36) and Cu content in folded leaves and stem (662.94 and 923.99)% respectively. 50 mg.l$^{-1}$ B profoundly exceeded 75 mg.l$^{-1}$ B in N content of folded leaves (1.65%), K content of folded and unfolded leaves (52.96 and 36.86%), Fe content of folded leaf bases (32.82%), Cu content in folded leaves and stem were (684.87 and 2524.92)% respectively and Ca content of folded leaves (80.55%). Untreated highly exceeded 25 mg.l$^{-1}$ B in B content of folded and unfolded leaves (128.63 and 58.26)% respectively, N content of stem (108.51%), K content of unfolded leaves, stem and folded leaf bases were (72.57, 31.21 and 61.43)% respectively. This treatment substantially surpassed 50 mg.l$^{-1}$ B in B content of unfolded leaves and stem were (13.68 and 4.56)% respectively, N content of stem (53.13%), K content of stem and folded leaf bases (35.7 and 83.52)% respectively, Cu content of unfolded leaves (108.39)% respectively, and Ca content of stem and folded leaf bases (63.6 and 134.85)% respectively. Untreated plants also preponderates on 75 mg.l$^{-1}$ B plants in B content of unfolded leaves and stem (27.31 and 22.81)% respectively, N content of stem (44.97%), K content of unfolded leaves, stem and folded leaf bases (47.17, 25.07 and 68.18%), Ca content of folded leaves, stem and folded leaf bases (53.88, 48.75 and 116.27)% respectively.

### *C. Lettuce seed quality and seed yield:*

Table (4) showed the influence of Boron levels (mg.l$^{-1}$) and mulching on seed quality and seed yield. Data revealed that 25 mg.l$^{-1}$ B treatment showed superiority over other treatments, since it highly exceeded control and 50 mg.l$^{-1}$ B in seeds yield per plant and seed yield.m$^{-2}$ (53.63%). Additionally, it highly exceeded 75 mg.l$^{-1}$ B in seeds yield per plant and seed yield.m$^{-2}$ (166.98%). [23] demonstrated that boron was more critical for pollen tube elongation than for pollen germination. Rapid growth of pollen tube depends on constant fusion of vesicles forming the plasma lemma, and continuous secretion of cell wall material. [24] proposed that the "capture" of secreted pollen proteins for membrane and wall building, proceeds through borate complexes with sugar residues. Pollen of *Petunia* contains many glycoproteins, and the oligosaccharides of plant glycoproteins contain significant amounts of mannose and fructose, both known to form stable esters with borate. Protein secretion was investigated during pollen tube growth of *Petunia* at different temperatures. It was observed that the phase change patterns of lipids in membranes were completely different when boron was present in the medium. This could be related to the fact that in the presence of boron, a greater proportion of the protein was assembled into the membrane and wall matrices. It was also noted that pollen tube germination was completely inhibited at temperatures over 21ºC unless boron was present. This could explain the importance of boron in reproductive growth of warm season crops, like maize [25].

Table -4: The influence of Boron levels (mg.l$^{-1}$) and mulching on seed quality and seed yield.

| ***Boron (mg.l$^{-1}$)*** | ***Data superiority%*** | | |
|---|---|---|---|
| ***The exceeded treatments*** | ***Weight of 1000 Seeds (g)*** | ***Seed yield.pl$^{-1}$ (g)*** | ***Seed yield.m$^{-2}$ (g)*** |
| ***Bare soil/Mulching*** | *28.13* | *N.S* | *N.S* |
| ***0/25*** | *26.23* | *N.S* | *N.S* |
| ***0/50*** | *12.00* | *N.S* | *N.S* |
| ***0/75*** | *25.37* | *N.S* | *N.S* |
| ***25/0*** | *N.S* | *53.63* | *53.63* |
| ***25/50*** | *N.S* | *53.63* | *53.63* |
| ***25/75*** | *N.S* | *166.98* | *166.98* |

N.S Denote that there is no superiority

***D. Lettuce responses to Boron levels and mulching:***

Table (5) showed the influence of Boron levels ($mg.l^{-1}$) and mulching on vegetative growth parameters. The data revealed that lettuce plants treated with $75mg.l^{-1}$ and grown on bare soils were the best dual interaction as compared to others. It showed the highest values or very closes value to the highest ones in head $yield.m^{-2}$, head fresh weight, number of folded leaves, weight of folded leaves, TSS of folded leaves, branches height and dry matter percentage of unfolded leaves (4.5Kg, 750g, 41.25, 440g, 6.8%, 54cm and 8.99)% respectively. Lettuce plants treated with $75mg.l^{-1}$ and grown on bare soils was the best dual interaction as compared to other. It showed the highest values or very close values to the highest ones in B in unfolded leaves ($22.48g.Kg^{-1}$), N content of folded leaf bases (3.6%), Fe content of folded leaves and folded leaf bases ( 299.38 and 331.88 $g.Kg^{-1}$, respectively). Lettuce treated with 25 $mg.l^{-1}$ B grown on bare soil gave the highest seeds weight for an individual plant, seeds $yield.m^{-2}$ (220 and 1320g) respectively, as compared to other dual interactions. High temperature was found to alter the nutrient mobilization and their availabilities to plant in root zones. Mineralization [i.e. the conversion of organic nitrogen (N) to inorganic (N)] of composted container substrates is also affected by high temperatures [26]. Both nitrate ($NO^{-3}$) and ammonium ($NH_4^+$) are inorganic forms of N that can be taken up and metabolized by plants [27]. Nitrate is often a preferential source for plants, but much depends on the plant species and other environmental factors. A number of reports indicate that the uptake of both N-forms is temperature dependent, rates of uptake being depressed by lower temperatures [28]. Most of the N mineralization studies have been conducted using soil temperatures found in field production. Mineralization of organic N is microbially mediated and the rate of nutrient availability is regulated by environmental conditions such as temperature, moisture and pH [29]. Since temperatures of container substrates can reach (39 °C) and higher, mineralization rates under these conditions will be quite different from field conditions. Primary cell wall structure and membrane function now closely linked to boron nutrition. In contrast, boron role in plant metabolism is still a subject of considerable debate. Focusing on the diversity of early responses to boron deficiency, [30] postulated that boron can be involved in a number of metabolic pathways and can act in regulation of metabolic processes similarly to plant hormones. However, due to a lack of suitable information, boron function in metabolic events has never been properly evaluated. There is substantial evidence supporting the association of boron with ascorbate metabolism.

Table -5: The influence of Boron levels ($mg.l^{-1}$) and mulching on vegetative growth parameters.

| Vegetative growth parameters | B ($mg.l^{1}$) | Mulching | Bare soil | Means |
|---|---|---|---|---|
| Head Fresh Weight (g) | 0 | 555.25b | 513.75b | 534.5a |
| | 25 | 482.5b | 602.5b | 542.5a |
| | 50 | 550.75b | 623.75ab | 587.25a |
| | 75 | 481.25b | 750a | 615.63a |
| Means | | 517.44 b | 622.5a | |
| Yield.$m^{-2}$ (kg) | 0 | 3.33b | 3.08b | 3.21a |
| | 25 | 2.9b | 3.62b | 3.26a |
| | 50 | 3.3b | 3.74ab | 3.52a |
| | 75 | 2.89b | 4.5a | 3.69a |
| Means | | 3.1b | 3.74a | |
| Heading (%) | 0 | 100 | 100 | 100 |
| | 25 | 100 | 100 | 100 |
| | 50 | 100 | 100 | 100 |
| | 75 | 100 | 100 | 100 |
| Means | | 100 | 100 | |
| Tip burn (%) | 0 | 0.00 | 0.00 | 0.00 |
| | 25 | 0.00 | 0.00 | 0.00 |
| | 50 | 0.00 | 0.00 | 0.00 |
| | 75 | 0.00 | 0.00 | 0.00 |
| Means | | 0.00 | 0.00 | |
| Bitterness (%) | 0 | 0.00 | 0.00 | 0.00 |
| | 25 | 0.00 | 0.00 | 0.00 |
| | 50 | 0.00 | 0.00 | 0.00 |
| | 75 | 0.00 | 0.00 | 0.00 |
| Means | | 0.00 | 0.00 | |
| Folded Leaves no.(l/pl) | 0 | 23.5c | 33abc | 28.25a |
| | 25 | 32.25abc | 37.5ab | 34.88a |
| | 50 | 28.25bc | 32.7abc | 30.5a |
| | 75 | 31.5abc | 41.25a | 36.38a |
| Means | | 28.88b | 36.13a | |
| Weight of Folded Leaves(g) | 0 | 267.5bc | 233.75bc | 250.63a |
| | 25 | 322b | 295bc | 308.5a |
| | 50 | 253.5bc | 295bc | 274.25a |
| | 75 | 183.25c | 440a | 311.63a |
| Means | | 256.56b | 315.94a | |
| Stem Length (cm) | 0 | 14.51c | 14.38c | 14.44b |
| | 25 | 9.95d | 20.25b | 15.1b |
| | 50 | 10.75d | 26.63a | 18.69a |
| | 75 | 10.48d | 20.5b | 15.49b |
| Means | | 11.42b | 20.44a | |
| Stem Diameter (cm) | 0 | 2.79b | 3.4ab | 3.1b |
| | 25 | 3.15ab | 3.48ab | 3.31ab |
| | 50 | 3.72ab | 3.05ab | 3.39ab |
| | 75 | 4.35a | 3.85ab | 4.1a |
| Means | | 3.5a | 3.44a | |
| TSS (%) Folded Leaves | 0 | 5.13ab | 4.1b | 4.61b |
| | 25 | 4.68ab | 5.68ab | 5.18ab |
| | 50 | 5.9ab | 6.58a | 6.24a |
| | 75 | 6.25a | 6.8a | 6.53a |
| Means | | 5.49a | 5.79a | |

| | | | | | |
|---|---|---|---|---|---|
| TSS (%) | Stem | 0 | 4.23b | 4.15b | 4.19b |
| | | 25 | 5.1ab | 4.78ab | 4.94ab |
| | | 50 | 6.33a | 5.65ab | 5.99a |
| | | 75 | 4.18b | 5.35ab | 4.76ab |
| Means | | | 4.96a | 4.98a | |
| TSS (%) | Folded leaf bases | 0 | 4.4abc | 3.35bc | 3.88ab |
| | | 25 | 3.2c | 4.15abc | 3.68b |
| | | 50 | 4.8a | 4.75ab | 4.78a |
| | | 75 | 3.95abc | 4.35abc | 4.15ab |
| Means | | | 4.09a | 4.15a | |
| Branch No. After Chopping | | 0 | 10.04a | 7.75c | 8.91a |
| | | 25 | 5.78d | 7.7c | 6.74c |
| | | 50 | 6.85c | 9.25ab | 8.05b |
| | | 75 | 7.33c | 8.75b | 8.04b |
| Means | | | 7.51b | 8.36 a | |
| Branch Height (cm) | | 0 | 55.25a | 34.75c | 45b |
| | | 25 | 55.25a | 59.25a | 57.25a |
| | | 50 | 34.25c | 44.5b | 39.38c |
| | | 75 | 44b | 54a | 49b |
| Means | | | 47.19a | 48.13a | |
| Leaf Number on Stem | | 0 | 47c | 49.75c | 48.38b |
| | | 25 | 66.25b | 79.5a | 72.88a |
| | | 50 | 27.75d | 70b | 48.88b |
| | | 75 | 43.5c | 64.5b | 54b |
| Means | | | 46.13b | 65.94a | |
| Dry matter (%) | Unfolded Leaves | 0 | 7.03b | 7.48ab | 7.26ab |
| | | 25 | 6.2b | 6.69b | 6.45b |
| | | 50 | 5.93b | 6.98b | 6.45b |
| | | 75 | 6.78b | 8.99a | 7.88a |
| Means | | | 6.49 b | 7.53 a | |

Means with the same letters are non-significantly different according to Duncan's multiple ranges test at 5% level.

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