



## The Influence of Mulching and GA<sub>3</sub>+Iron Mixture on Head Folding, Bitterness and Quality of Produced Seeds of Lettuce *Lactuca sativa* var. *Longifolia* cv. Marul

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### Abstract

This study was carried out during the period between November, 2013 and August, 2014 to decrease unfolding, bitterness and tip burns through adopting a new screening method and to produce lettuce seeds and head yields of high qualities. Seeds and plants raised from them were treated with mixtures of [0 and 10 mg.l<sup>-1</sup> GA<sub>3</sub> + 25 mg.l<sup>-1</sup> Fe, 10 mg.l<sup>-1</sup> GA<sub>3</sub> + 50 mg.l<sup>-1</sup> Fe and 10 mg.l<sup>-1</sup> GA<sub>3</sub> + 75mg.l<sup>-1</sup> Fe]. Plants grown on mulched and unmulched soils. Mulched soil plants displayed superiority over bare soil in terms: number of unfolded leaves, stem length and leaves number by 48.75, 110.85 and 22.23%, respectively. However, unmulched soil bypassed mulched soil in T.S.S. and dry matter percentages of folded leaves, unfolded leaves, stem and folded leaf base (23.96, 19.41, 30.59, 22.17, 18.52, 28.6, 18.54 and 27.24%, respectively). Lettuce grown on mulched soil revealed superiority over that grown on bare soil in N content of folded and unfolded leaves (23.1 and 68.75%, respectively), K content of folded leaves, stem and folded leaf base (57.85, 42.02 and 24.43%, respectively), Fe content of stem and folded leaf base (106.11 and 54.02 g.kg<sup>-1</sup>, respectively), Ca content of folded leaves, unfolded leaves, stem and folded leaf base (424.09, 235.96, 206.02 and 296.78%, respectively). 10 mg.l<sup>-1</sup> GA<sub>3</sub> + 75 mg.l<sup>-1</sup> Fe displayed preponderance over untreated plants in head fresh weight (26.43%), head yield (26.16%), TSS (15.52%), branches number after chopping (92.9%), branch heights (66.98%) leaf number (30.82%), B content of folded leaves and stem (143.23 and 57.89%, respectively), N content of the folded leaf base (49.73%), K content of folded leaves (7.15%), Fe content of stem (152.14%) and Cu content of stem (39.54%). Lettuce plant treated by 10 mg.l<sup>-1</sup> GA<sub>3</sub> + 50 mg.l<sup>-1</sup> Fe grown on mulched soil overwhelmed other dual interaction treatments as it showed the highest values in head fresh weight (821 g), head yield.m<sup>-2</sup> (4.93 kg), weight of folded leaves (483.75 g), number of unfolded leaves (23.75) and weight of unfolded leaves (335 g).

### Introduction

Lettuce (*Lactuca sativa* L.) native to the Mediterranean area and was domesticated in Egypt around 4,500 B. C. Lettuce is believed to be one of the first vegetables brought to the new world and has been grown in the United States since colonial times [1]. Today, in terms of production value, it is the leading vegetable crop in the United States. More than 90 percent of U.S. lettuce production is located in California and Arizona. The main varieties include iceberg, romaine and various leaf varieties [2]. Today, Arizona ranks second,

following California, in production of lettuce. Lettuce production in Arizona is the State's leading cash crop averaging more than \$300 million in value. There are approximately 75,000 acres of lettuce grown in the southwestern United States [3].

Mulch films have been reported to maintain soil moisture [4], reduce soil compaction [5] and control weeds if opaque to photosynthetically active radiation [6]. The most commonly used opaque mulch, black polyethylene, may not be the most appropriate for use in a cool season crop such as lettuce, because of its soil warming capacity. A coextruded white/black polyethylene may be better adapted to this crop since its upper surface reflects incoming light, thereby reducing surface temperatures, and its black underside reduces weed growth [7]. The variety of positive effects of PE mulch makes it highly suitable for sustainable vegetable production aiming at reduction of nutrient and pesticides use [8].

Iron is an essential element required for respiration, photosynthesis, and many other cellular functions such as DNA synthesis, nitrogen fixation, and hormone production. Although abundant in nature, iron often is unavailable because it forms insoluble ferric hydroxide complexes in the presence of oxygen at neutral or basic pH [9]. In contrast, anaerobic conditions in acidic soils can lead to cellular iron overload, which causes serious damage to plants because free iron catalyzes the formation of reactive oxygen species [9, 10, 11].

Several authors have noticed that treatment with GA increases leaf extension zone LEZ length alone without increasing maximum relative elemental growth rates REGR [12, 13], while others have found increases in both the distance over which cells expand and the maximum REGR [14, 15].

The objectives of this study were to produce head yields of lettuce and lettuce seeds of high quality, devoid of bitterness and higher heading percentages under rainfall incidences of Sulaimani province, Kurdistan region, Iraq. All treatments were tested under the influences of rainfall incidences, mulching by black polyethylene.

## **Material and methods:**

### **Experiments location and chosen cultivars**

This study was carried out during the period between November, 2013 and May, 2014 at Bakrajo Research Field, Horticulture Department, Faculty of Agricultural Sciences, University of Sulaimani Sulaymaniyah Governorate, Kurdistan Region, Iraq. The field is located on Latitude ( $35^{\circ}$ ,  $32.134'$  N), Longitude ( $45^{\circ}$ ,  $21.879'$  E) and altitude (732 meters above sea level). Lettuce (*Lactuca sativa* L.) was evaluated for lowest bitterness, unfolded and physiological disorder incidences. Subsequently, the seeds were purchased from Agricultural Bureau, Sulaymaniyah where Marul seeds were produced by Argeto Company for vegetable seed production, under lot number TR7913120AY, germination percentage was 83% and seed purity was 99%.

The experimental design was Split Plot within Factorial Randomized Complete Block Design (Split F-RCBD), where the main plots (A) was bare soil ( $a_1$ ) and soil mulched with black polyethylene ( $a_2$ ). Whereas, the sub main plots (B) were mixtures of  $GA_3$  0  $mg.l^{-1}$  + 0  $mg.l^{-1}$  Fe ( $b_1$ );  $GA_3$  10  $mg.l^{-1}$  + 25  $mg.l^{-1}$  Fe ( $b_2$ );  $GA_3$  10  $mg.l^{-1}$  + 50  $mg.l^{-1}$  Fe ( $b_3$ ) and  $GA_3$  10  $mg.l^{-1}$  + 75  $mg.l^{-1}$  Fe ( $b_4$ ).

### **Vegetative growth and reproductive parameters:**

Stem length (cm), stem diameter (cm) branches length (cm) were measured by ruler and caliper. Unfolded leaves, folded leaves, branch number of chopped heads, number of leaves on forming branches, branch number of inflorescence were counted. Head fresh weight (g), yield of head fresh weight ( $kg.m^{-2}$ ) fresh weight of folded (g), weight of unfolded leaf base (g), fresh weight of unfolded leaves (g), the yield of a meter square (g), individual plant (g), weight of 1000 seeds (g) were weighed by four decimal electrical balances. Folded leaves, unfolded leaves, stem and leaf bases were weighed and then oven dried at  $55^{\circ}C$  for 48 hrs then reweighed to calculate their dry matter percentages.

### **Total Soluble Solids and Chlorophyll**

Total Soluble Solids of plant parts were measured by hand Refractometer, while chlorophyll percentage out of the gross pigments of folded and unfolded leaves as spad value measured by Chlorophyll Meter (model spad 502).

### **Mineral determination**

0.2 g powder dry weight sample was digested by adding 10ml concentrated sulfuric acid ( $H_2SO_4$ ) then 10 ml of  $H_2O_2$  was added then the samples were heated until being clear and thereafter transferred to 50ml volumetric flask, the final sample was brought to 50ml with adding of distilled water. Iron, copper and calcium were determined by Atomic Absorption Spectrophotometer. Sodium and potassium were determined by Flame Photometer. Boron in plant samples was determined by dry digestion, ash [16] and subsequently by colorimeter using Azomethine-H [17].

### **Total Nitrogen determination**

Nitrogen percentages were determined according to by Kjeldahl [18].

## **Results and discussion**

### **Lettuce responses to mulching:**

Mulched soil plants (Table 1) displayed superiority over bare soil in terms number of unfolded leaves and leaf number on stem by 48.75 and 22.23%. However, unmulched soil bypassed mulched soil with black polyethylene in T.S.S. and dry matter percentage of folded leaves, unfolded leaves, stem and folded leaf base (23.96, 19.41, 30.59, 22.17, 18.52, 28.6, 18.54 and 27.24%, respectively) (Tables 2 and 4) and in mineral contents, B content of folded leaves (305.56%), K content of unfolded leaves (9.66%), Fe content of folded and unfolded leaves (27.99 and 42.64%, respectively), Cu content of folded and unfolded leaves (208.6 and 47.35%, respectively) (Table 5) and N content of stem (15.64%) (Table 4). Lettuce grown on black polyethylene mulched soil revealed superiority over that grown on bare soil in N content of folded and unfolded leaves (23.1 and 68.75%, respectively) (Table 4), K content of folded leaves, stem and folded leaf base by (57.85, 42.02 and 24.43%, respectively), Fe content of stem and folded leaf base (106.11 and 54.02, respectively), Cu content of folded leaf base (66.98%), Ca content of folded leaves, unfolded leaves, stem and folded leaf base (424.09, 235.96, 206.02 and 296.78%, respectively) (Tables 5 and 6). The positive response of growth and mineral content of lettuce may be referred to the influences of black polyethylene mulch on root performances under such optimal environment conditions. Mulching is considered an agro-technical procedure which can significantly modify microclimate around plants. Black films, commonly used for this purpose, reduce weeding, limit evaporation and increase soil temperature. Transparent films have greater effect on soil temperature as compared to white and other light-reflecting films [19]. Furthermore, film and fabric mulches decrease the degree of soil kneading, keeping it in good structure throughout the whole vegetation period [20].

### **Lettuce response to $GA_3$ + Iron mixtures:**

10 mg.l<sup>-1</sup> $GA_3$ +75mg.l<sup>-1</sup> Fe displayed preponderances over untreated plants in terms of branches number after chopping (92,9%), branch heights (66.98%) and leaf number on stem (30.82%) (Table 1), head fresh weight (26.43%), head yield (26.16%) (Table 2) and TSS of stem (15.52%) (Table 4). 10 mg.l<sup>-1</sup>  $GA_3$ +75mg.l<sup>-1</sup> Fe displayed preponderances over 10 mg.l<sup>-1</sup>  $GA_3$ +25mg.l<sup>-1</sup> Fe in head fresh weight (37.08%), yield per square meter (36.91%) (Table 2), TSS of stem (3.23%) (Table 4), branches number after chopping (60.44%) and branch height (36.72%) (Table 1), 10 mg.l<sup>-1</sup>  $GA_3$  +75 mg.l<sup>-1</sup> Fe also exceeded 10 mg.l<sup>-1</sup>  $GA_3$  +50 mg.l<sup>-1</sup> Fe in

head fresh weight (6.57%), head yield (6.37%) (Table 2), TSS of stem (18.96%), TSS of folded leaf base (24.38%) (Table 4), branches number after chopping (28.21%), branch height (13.14%) and leaf number on stem (50.39%) (Table 1). 10 mg.l<sup>-1</sup>GA<sub>3</sub> +50 mg.l<sup>-1</sup> Fe significantly preponderated untreated in head fresh weight (18.64%), head yield (18.6%) (Table 2), weight of folded leaves (37.25%), branches number after chopping (50.46%) and branch heights (47.59%) (Table 1). 10 mg.l<sup>-1</sup> GA<sub>3</sub> +50mg.l<sup>-1</sup> Fe significantly preponderated 10 mg.l<sup>-1</sup> GA<sub>3</sub>+25mg.l<sup>-1</sup> Fe in head fresh weight (28.63%), head yield (28.71%) (Table 2), weight of folded leaves (30.15%), branches number after chopping (25.14%) and branch heights (20.84%), 10 mg.l<sup>-1</sup> GA<sub>3</sub> + 50 mg.l<sup>-1</sup> Fe exceeded 10 mg.l<sup>-1</sup>GA<sub>3</sub> +75mg.l<sup>-1</sup> in weight of folded leaves (11.29%). 10 mg.l<sup>-1</sup> GA<sub>3</sub> +25mg.l<sup>-1</sup> Fe substantially surpassed untreated in branches number after chopping (20.24%), branch height (22.13%) and leaf number on stem (23.64%) (Table 1). This treatment also exceeded 10 mg.l<sup>-1</sup> GA<sub>3</sub> +50mg.l<sup>-1</sup> in TSS of folded leaf base (19.41%) (Table 4) and leaf number on stem (42.14%) (Table 1). Untreated lettuce plants was superior over 10 mg.l<sup>-1</sup> GA<sub>3</sub> +25mg.l<sup>-1</sup> Fe in stem length (12.06%) and stem diameter (4.02%) (Table 1). Untreated plants also bypassed 10 mg.l<sup>-1</sup> GA<sub>3</sub> +50 mg.l<sup>-1</sup> Fe in stem length (17.25%), stem diameter (20.43%) (Table 1) and TSS of folded leaf base (26.64%)(Table 4). Untreated plants highly exceeded 10 mg.l<sup>-1</sup> GA<sub>3</sub> +75 mg.l<sup>-1</sup> Fe in stem length and stem diameter (38.76 and 9.8%, respectively) (Table 1). [21] manifested that combination mixture of 20 g.m<sup>-2</sup> urea + 10 mg l<sup>-1</sup> Fe-EDDHA + 50 mg l<sup>-1</sup>GA<sub>3</sub> was the most effective treatment. It gave the highest values in term of plant height, leaf numbers per plant, leaf fresh weight per plant and marketable yield.

10 mg.l<sup>-1</sup> GA<sub>3</sub>+75 mg.l<sup>-1</sup> Fe displayed preponderances over untreated in N content of folded leaf base (49.73%) (Table 4), also in terms of B content, folded leaves and stem (143.23 and 57.89%, respectively), K content of folded leaves (7.15%), Fe content of stem (152.14%) and Cu content of stem (39.54%). This treatment revealed prevalence over 10 mg.l<sup>-1</sup> GA<sub>3</sub> +25mg.l<sup>-1</sup> Fe in Boron content of stem (38.52%), K of folded leaves (13.24%), Fe content of stem (156.9%) and Cu content of stem (36.75%), 10 mg.l<sup>-1</sup> GA<sub>3</sub> +75mg.l<sup>-1</sup> Fe prevailed over 10 mg.l<sup>-1</sup> GA<sub>3</sub> +50 mg.l<sup>-1</sup> Fe in B content in stem (54.54%), K content of folded leaves (20.06%), Fe content of stem (251.02%) and Cu content of stem (143.11%) (Tables 5 and 6). 10 mg.l<sup>-1</sup> GA<sub>3</sub> +50mg.l<sup>-1</sup> Fe displayed preponderances over untreated in Nitrogen content of unfolded leaves, stem and folded leaf base (7.58, 29.29 and 114.75%, respectively) (Table 4), also in terms B content of folded leaves (108.06), K content of unfolded leaves and folded leaf base (21.11 and 47.28%, respectively), Fe content of unfolded leaves (32.1%), Cu content of folded leaves (44.4%) and Ca content of folded leaf base (35.01%) (Tables 5 and 6). 10 mg.l<sup>-1</sup>GA<sub>3</sub> +50 mg.l<sup>-1</sup> Fe displayed preponderances over 10 mg.l<sup>-1</sup> GA<sub>3</sub> +25 mg.l<sup>-1</sup> Fe, in terms N content of unfolded leaves (19.13%) (Table 4). 10 mg.l<sup>-1</sup> GA<sub>3</sub>+50mg.l<sup>-1</sup> Fe displayed preponderances over 10 mg.l<sup>-1</sup> GA<sub>3</sub> + 75 mg.l<sup>-1</sup> Fe in terms B content of unfolded leaves and folded leaf base (59.32 and 68.34%, respectively) (Tables 5 and 6), N content of unfolded leaves, stem and folded leaf base (15.26, 43.72 and 43.43%, respectively) (Table 4), K content of unfolded leaves and folded leaf base (9.55 and 18.22%, respectively), Fe content of unfolded leaves (23.12%), Cu content of folded leaves and unfolded leaves (23.3 and 54.96%, respectively) and Ca content of stem and folded leaf base (31.82 and 68.31%, respectively) (Tables 5 and 6). 10 mg.l<sup>-1</sup>GA<sub>3</sub> +25mg.l<sup>-1</sup> Fe profoundly exceeded untreated in N content of stem and folded leaf base (19.25 and 103.83%, respectively) (Table 4), also in B content of folded leaves (111.61%), K content of unfolded leaves and folded leaf base (26.37 and 32.16%, respectively), Fe content of unfolded leaves and folded leaf base (49.01 and 91.04%, respectively), Cu content of folded leaves (61.1%), Ca content of unfolded leaves and folded leaf base (17.14 and 62.86%, respectively) (Tables 5 and 6). 10 mg.l<sup>-1</sup> GA<sub>3</sub>+25mg.l<sup>-1</sup>Fe profoundly surpassed 10 mg.l<sup>-1</sup> GA<sub>3</sub> +50 mg.l<sup>-1</sup> Fe, in K of unfolded leaves (4.35%), Fe content of unfolded leaves (12.8%), Fe content of folded leaf base (127.55%), Cu content of folded leaves, unfolded leaves and folded leaf base (11.57,66.18 and 77.78%, respectively), Ca content of folded leaves, unfolded leaves and folded leaf base (14.88, 7.74 and 20.62%, respectively) (Tables 5 and 6). 10 mg.l<sup>-1</sup> GA<sub>3</sub> +25 mg.l<sup>-1</sup> Fe substantially overwhelmed 10 mg.l<sup>-1</sup> GA<sub>3</sub> +75mg.l<sup>-1</sup> Fe in N content of stem and folded leaf base (32.56 and 36.13%, respectively) (Table 4), B content of unfolded leaves and folded leaf base (66.32 and 54.17%, respectively), K content of unfolded leaves and folded leaf base (14.31 and 6.09%, respectively), Fe content of unfolded leaves and folded leaf base (38.88 and 141.72%, respectively), Cu

content of folded leaves and unfolded leaves (37.57 and 157.51%, respectively), Ca content of folded leaves, unfolded leaves, stem and folded leaf base (13.34, 36.24, 48.13 and 103.03%, respectively) (Tables 5 and 6). Untreated plants highly exceeded  $10 \text{ mg.l}^{-1} \text{ GA}_3 + 25 \text{ mg.l}^{-1} \text{ Fe}$ , in N content in folded and unfolded leaves (17.14 and 10.74%, respectively), also Untreated plants exceeded  $10 \text{ mg.l}^{-1} \text{ GA}_3 + 50 \text{ mg.l}^{-1} \text{ Fe}$  in N content of folded leaves (21.89%) (Table 4), Cu content of unfolded leaves and stem (63.99 and 74.22%, respectively), Ca content of folded leaves (26.87%) (Tables 5). Untreated plants exceeded  $10 \text{ mg.l}^{-1} \text{ GA}_3 + 75 \text{ mg.l}^{-1} \text{ Fe}$  in N content of folded leaves and unfolded leaves (19 and 7.14%, respectively) (Tables 4), B content of unfolded leaves and folded leaf base (56.05 and 75.89%, respectively), Cu content of unfolded leaves (154.11%) and Ca content of folded leaves, stem and folded leaf base (25.18, 52.35 and 24.66%, respectively) (Tables 5 and 6). These results might be attributed to the role iron in cell metabolism since iron is an essential element required for respiration, photosynthesis, and many other cellular functions such as DNA synthesis, nitrogen fixation, and hormone production. Although abundant in nature, iron often is unavailable because it forms insoluble ferric hydroxide complexes in the presence of oxygen at neutral or basic pH [9].

#### **Lettuce response to $\text{GA}_3$ + Iron mixtures and mulching:**

Lettuce plants treated by  $10 \text{ mg.l}^{-1} \text{ GA}_3 + 50 \text{ mg.l}^{-1} \text{ Fe}$  grown on mulched soil overwhelmed other dual interaction treatments as it showed the highest values in number of unfolded leaves (23.75) weight of folded leaves (483.75g) and weight of unfolded leaves (335g) (Table 1), head fresh weight (821g), head yield.m<sup>-2</sup> (4.93 Kg) (Table 2). This dual also interaction also showed the highest N content of unfolded leaves, stem and folded leaf base (4.31, 2.79 and 4.38%, respectively) (Table 4), K content of stem and folded leaf base (44.42 and 63.49 g.kg<sup>-1</sup>, respectively), Fe content of folded leaves (196.88 g.kg<sup>-1</sup>), Ca of unfolded leaves and stem (7824.4 and 2744.4 g.kg<sup>-1</sup>) (Tables 5 and 6). These results might be due to the role of black polyethylene to allow a water layer to form under the mulch and it is this water layer that slows down the loss of the moisture. Radish yield linearly responded to iron rates. the highest two iron rates profoundly increased particularly,  $40 \text{ mg.l}^{-1}$ . Root fresh weight is linearly responded to iron rate [22].  $50 \text{ mg.L}^{-1} \text{ GA}_3$  was the most effective rate under supplementary irrigation, however, under rainfed  $150 \text{ mg.L}^{-1} \text{ GA}_3$  was the superior rate. Since these two rates gave the highest yield of green pods.  $\text{GA}_3$  application tended to lengthen juvenility and delayed pod maturation and its combination with supplemental watering led to plant lodge particularly with  $150 \text{ mg.L}^{-1} \text{ GA}_3$  rate, albeit their yield improvement. Under rainfed cultivation,  $150 \text{ mg.L}^{-1} \text{ GA}_3$  rate profoundly increased drought resistance ability, but it failed to face earlier maturity brought about by drought episodes.

#### **Lettuce seed productions response to Gibberellic acid and Iron mixture rates**

Non-significant differences were observed between different levels of Gibberellic acid and Iron mixtures (Table 7) in the seed yield of individual plant, seed yield per m<sup>-2</sup> and weight of 1000 seeds.

#### **Conclusions:**

Lettuce plants treated with Gibberellic acid  $\text{GA}_3$  mixed with iron were paramount in boosting well performed lettuce head, especially these treated by  $10 \text{ mg.l}^{-1} \text{ GA}_3 + 25 \text{ mg.l}^{-1} \text{ Fe}$  mixture which significantly surpassed untreated plants.

**Table 1.** The influence of mulching and GA<sub>3</sub>+ Iron mixture (mg.l<sup>-1</sup>) on vegetative characteristics of lettuce *Lactuca sativa* var. longifolia cv. Marul

Parameters/ GA <sub>3</sub> + Iron mixture (mg.l <sup>-1</sup> )	Mulched	Unmulched	Means	
Folded Leaves no. (l/pl)	0	23.5a	34a	28.75a
	10+25	35.25a	34.25a	34.75a
	10+50	25.25a	36a	30.63a
	10+75	30.75a	29a	29.88a
Means		28.69a	33.31a	
Weight of Folded Leaves (g)	0	267.5b	296.25b	281.88b
	10+25	285b	318.75b	301.88ab
	10+50	483.75a	290b	386.88a
	10+75	351.5ab	343.75ab	347.63ab
Means		346.94a	312.19a	
Unfolded Leaves no. (l/pl)	0	14.5b	19b	16.75a
	10+25	22.5ab	12.25b	17.38a
	10+50	23.75ab	15.75b	19.75a
	10+75	32.25a	15.5b	23.88a
Means		23.25a	15.63b	
Weight of Unfolded Leaves (g/pl)	0	239.25ab	233.75ab	236.5a
	10+25	277ab	162.5b	219.75a
	10+50	335ab	191.25ab	263.13a
	10+75	399.5a	278ab	338.75a
Means		312.69a	216.38a	
Stem Length (cm)	0	12.53c	26.5a	19.51a
	10+25	12.08c	22.75ab	17.41ab
	10+50	12.78c	20.5b	16.64ab
	10+75	6.13d	22ab	14.06b
Means		10.88b	22.94a	
Stem Diameter (cm)	0	3.68a	3.05ab	3.36a
	10+25	3.08ab	3.38a	3.23ab
	10+50	2.61b	2.98ab	2.79b
	10+75	2.49b	3.63a	3.06ab
Means		2.96a	3.26a	
Branch No. After Chopping	0	9.48c	5.75e	7.61d
	10+25	7.8d	10.5c	9.15c
	10+50	10.4c	12.5b	11.45b
	10+75	14.35a	15a	14.68a
Means		10.51a	10.94a	
Branch Height (cm)	0	36.5d	46c	41.25d
	10+25	39.5d	61.25b	50.38c
	10+50	64b	57.75b	60.88b
	10+75	80a	57.75b	68.88a
Means		55a	55.69a	
Leaf Number on Stem	0	37.5cd	35.5cd	36.5b
	10+25	41.5bc	48.75b	45.13a
	10+50	34.75cd	28.75d	31.75b
	10+75	63.5a	32cd	47.75a
Means		44.31a	36.25b	

**Table 2.** The influence of mulching and GA<sub>3</sub>+ Iron mixture (mg.l<sup>-1</sup>) on yield and its components in lettuce *Lactuca sativa* var. longifolia cv. Marul

Parameters/ GA <sub>3</sub> + Iron mixture (mg.l <sup>-1</sup> )		Mulched	Unmulched	Means	
Head Fresh Weight (g)	0	573bc	572.5bc	572.75bc	
	10+25	496.5c	560bc	528.25c	
	10+50	821a	538bc	679.5ab	
	10+75	734.5ab	713.75abc	724.13a	
Means		656.25a	596.06a		
Yield.m <sup>-2</sup> (kg)	0	3.34bc	3.44bc	3.44bc	
	10+25	2.98c	3.36bc	3.17c	
	10+50	4.93a	3.23bc	4.08ab	
	10+75	4.41ab	4.28abc	4.34a	
Means		3.94a	3.58a		
Heading (%)	0	100	100	100	
	10+25	100	100	100	
	10+50	100	100	100	
	10+75	100	100	100	
Means		100	100		
Dry matter (%)	Folded leaves	0	6.5c	8.04a	7.27a
		10+25	5.01d	7.68ab	6.35a
		10+50	5.83cd	6.99abc	6.41a
		10+75	7.08abc	7.4ab	7.24a
Means		6.1b	7.23a		
Dry matter (%)	Unfolded leaves	0	5.65bc	8.15a	6.9a
		10+25	5.26c	7.49ab	6.38a
		10+50	6.14abc	7.87a	7a
		10+75	7.16abc	7.6ab	7.38a
Means		6.05b	7.78a		
Dry matter (%)	Stem	0	5.97bc	7.07abc	6.52a
		10+25	5.8bc	8.33a	7.06a
		10+50	5.43c	7.42ab	6.42a
		10+75	7.43ab	6.33bc	6.88a
Means		6.15b	7.29a		
Dry matter (%)	Folded Leaf Base	0	4.94c	6.95a	5.95a
		10+25	4.72c	6.5ab	5.61a
		10+50	4.79c	5.75bc	5.27a
		10+75	5.22c	5.83bc	5.27a
Means		4.92b	6.26a		

**Table 3.** The influence of mulching and GA<sub>3</sub>+ Iron mixture (mg.l<sup>-1</sup>) on tipburn and bitterness of lettuce *Lactuca sativa* var. longifolia cv. Marul

Parameters/ GA <sub>3</sub> + Iron mixture (mg.l <sup>-1</sup> )		Mulched	Unmulched	Means
Tip burn (%)	0	0.00	0.00	0.00
	10+25	0.00	0.00	0.00
	10+50	0.00	0.00	0.00
	10+75	0.00	0.00	0.00
Means		0.00	0.00	
Bitterness (%)	0	0.00	0.00	0.00
	10+25	0.00	0.00	0.00
	10+50	0.00	0.00	0.00
	10+75	0.00	0.00	0.00
Means		0.00	0.00	

**Table 4.** The influence of mulching and GA<sub>3</sub>+ Iron mixture (mg.l<sup>-1</sup>) on T.S.S., chlorophyll and nitrogen percentages of lettuce *Lactuca sativa* var. longifolia cv. Marul

Parameters/ GA <sub>3</sub> + Iron mixture (mg.l <sup>-1</sup> )		Mulched	Unmulched	Means	
TSS (%)	Folded leaves	0	5.3cd	7.2a	6.25a
		10+25	5.13d	6.9ab	6.01a
		10+50	5.53cd	6.8ab	6.16a
		10+75	6.18bc	6.48ab	6.33a
Means			5.53b	6.84a	
TSS (%)	Unfolded leaves	0	5.88ab	7.03a	6.45a
		10+25	4.93b	7.33a	6.13a
		10+50	4.93b	6.5ab	5.71a
		10+75	7.15a	6.45ab	6.8a
Means			5.72b	6.83a	
TSS (%)	Stem	0	4.65cd	6.43ab	5.54ab
		10+25	5.35bc	7.05a	6.2ab
		10+50	4.08d	6.68a	5.38b
		10+75	6.33ab	6.48ab	6.4a
Means			5.1b	6.66a	
TSS (%)	Folded Leaf Base	0	5.13ab	6.1a	5.61a
		10+25	4.48bc	6.1a	5.29a
		10+50	3.53c	5.33ab	4.43b
		10+75	5.63a	5.4ab	5.51a
Means			4.69b	5.73a	
Chlorophyll (%)	Folded leaves	0	7.2a	9.28a	8.24a
		10+25	12.28a	13.9a	13.09a
		10+50	9.48a	7.73a	8.6a
		10+75	12.23a	9.45a	10.84a
Means			10.29a	10.09a	
Chlorophyll (%)	Unfolded leaves	0	37.9a	35.58a	36.74a
		10+25	45.35a	33.33a	39.34a
		10+50	37.2a	34.75a	35.98a
		10+75	37.53a	37.a	37.26a
Means			39.49a	35.16a	
Nitrogen (%)	Folded leaves	0	5.02a	3.99d	4.51a
		10+25	4.49bc	3.22e	3.85b
		10+50	3.1ef	4.3cd	3.7b
		10+75	4.88ab	2.71f	3.79b
Means			4.37a	3.55b	
Nitrogen (%)	Unfolded leaves	0	4.35a	2.25d	3.3b
		10+25	3.87b	2.1e	2.98c
		10+50	4.31a	2.79c	3.55a
		10+75	3.69b	2.47d	3.08c
Means			4.05a	2.4b	
Nitrogen (%)	Stem	0	2.41b	2.37b	2.39b
		10+25	2.33b	3.37a	2.85a
		10+50	2.79ab	3.39a	3.09a
		10+75	2.18b	2.12b	2.15b
Means			2.43b	2.81a	
Nitrogen (%)	Folded Leaf Base	0	1.94c	1.72c	1.83c
		10+25	3.77ab	3.69ab	3.73a
		10+50	4.38a	3.49b	3.93a
		10+75	2.14c	3.35b	2.74b
Means			3.05a	3.06a	

**Table 5.** The influence of mulching and GA<sub>3</sub>+ Iron mixture (mg.l<sup>-1</sup>) on leaf mineral contents of lettuce *Lactuca sativa* var. longifolia cv. Marul.

Parameters/ GA <sub>3</sub> + Iron mixture (mg.l <sup>-1</sup> )	Folded leaves			Unfolded leaves			
	Mulched	Unmulched	Means	Mulched	Unmulched	Means	
Boron (mg.l <sup>-1</sup> )	0	0.24c	5.96b	3.1b	20.81a	18.39ab	19.6a
	10+25	0.61c	12.51a	6.56a	22.69a	19.09a	20.89a
	10+50	6.42b	5.96b	6.45a	15.27ab	24.75a	20.01a
	10+75	1.55c	13.53a	7.54a	8.33b	16.79ab	12.56b
Means		2.34b	9.49a		16.78a	19.76a	
Potassium (mg.l <sup>-1</sup> )	0	48.23a	22.8d	35.52ab	52.05cd	44.42d	48.23c
	10+25	40.6b	26.62cd	33.61ab	53.32c	68.58a	60.95a
	10+50	32.97c	30.43c	31.7b	54.59bc	62.22a	58.41ab
	10+75	48.23a	22.89cd	38.06a	50.77cd	55.86bc	53.32bc
Means		42.51a	26.93b		52.68b	57.77a	
Sodium (mg.l <sup>-1</sup> )	0	1.02a	0.74a	0.88a	1.28a	0.89a	1.08a
	10+25	1.25a	0.82a	1.03a	1.45a	1.96a	1.71a
	10+50	0.95a	0.79a	0.87a	1.25a	1.78a	1.52a
	10+75	0.99a	0.79a	0.89a	1.07a	2.06a	1.57a
Means		1.05a	0.79a		1.26a	1.67a	
Iron (g.kg <sup>-1</sup> )	0	209.38a	198.75a	204.06a	360bc	368.13bc	364.06c
	10+25	110b	251.88a	180.94a	306.25c	778.75a	542.5a
	10+50	196.88a	203.13a	200a	456.88bc	505b	480.94ab
	10+75	205a	269.38a	237.19a	342.5bc	438.75bc	390.63bc
Means		180.31b	230.78a		366.41b	522.66a	
Copper (g.kg <sup>-1</sup> )	0	N.D	9.81a	4.91c	7.69bc	10.25ab	8.97a
	10+25	4.13c	11.69a	7.91a	10.75a	7.44c	9.09a
	10+50	6.88b	7.31b	7.09ab	3.13d	7.8bc	5.47b
	10+75	1.56d	9.94a	5.75bc	0.31e	6.75c	3.53c
Means		3.14b	9.69a		5.47b	8.06a	
Calcium (g.kg <sup>-1</sup> )	0	3148.1a	756.8c	1952.44a	7957.5a	1345.4d	4651.5ab
	10+25	3078.8a	456.9d	1767.84a	7922.5a	2975c	5448.8a
	10+50	2692.5b	385.3d	1538.88b	7824.4a	2290.2bc	5057.3ab
	10+75	2533.1b	586.3cd	1559.72b	5821.3b	2177.7cd	3999.5b
Means		2863.13a	546.31b		7381.4a	2197.1b	

**Table 6.** The influence of mulching and GA<sub>3</sub>+ Iron mixture (mg.l<sup>-1</sup>) on mineral contents of stem and folded leaf bases of lettuce *Lactuca sativa* var. longifolia cv. Marul.

Parameters/ GA <sub>3</sub> + Iron mixture (mg.l <sup>-1</sup> )	Stem			Folded leaf base			
	Mulched	Unmulched	Means	Mulched	Unmulched	Means	
Boron (mg.l <sup>-1</sup> )	0	13.64b	13.11b	13.37b	16.74a	9.81b	13.28a
	10+25	14.39b	16.09ab	15.24b	13.34ab	9.94b	11.64a
	10+50	12.34b	14.99b	13.66b	9.45b	15.97a	12.71a
	10+75	21.41a	20.81a	21.11a	2.43c	12.68ab	7.55b
Means		15.44a	16.25a		10.49a	12.1a	
Potassium (mg.l <sup>-1</sup> )	0	50.77a	43.15ab	46.96a	31.7c	35.52c	33.61b
	10+25	55.86a	30.43b	43.15a	50.77ab	38.06bc	44.42a
	10+50	44.42ab	27.89b	36.15a	63.49a	35.52c	49.5a
	10+75	38.06ab	31.7b	34.88a	41.87bc	41.87bc	41.87ab
Means		47.28a	33.29b		46.96a	37.74b	
Sodium (mg.l <sup>-1</sup> )	0	1.45a	1.83a	1.64a	1.22a	1.73a	1.48a
	10+25	1.27a	1.1a	1.19a	1.1a	1.17a	1.14a
	10+50	1.5a	1.04a	1.27a	1.07a	0.97a	1.02a
	10+75	1.15a	1.63a	1.39a	0.94a	1.1a	1.02a

<b>Means</b>		1.34a	1.4a		1.08a	1.24a	
<b>Iron (g.kg<sup>-1</sup>)</b>	<b>0</b>	404.38b	236.88b	320.63b	316.88b	318.13b	317.5b
	<b>10+25</b>	323.75b	305.63b	314.69b	985.63a	227.5bc	606.56a
	<b>10+50</b>	225b	235.63b	230.31b	255.63bc	277.5bc	266.56b
	<b>10+75</b>	1301.25 a	315.63b	808.44a	190c	311.88b	250.94b
<b>Means</b>		563.59a	273.44b		437.03a	283.75b	
<b>Copper (g.kg<sup>-1</sup>)</b>	<b>0</b>	6c	9.69b	7.84b	10.81ab	7.25cd	9.03a
	<b>10+25</b>	6.19c	9.81b	8b	13.13a	5d	9.06a
	<b>10+50</b>	3.31d	5.69c	4.5c	9.81bc	5.94d	7.88a
	<b>10+75</b>	14.88a	7c	10.94a	8.94bc	7.38cd	8.16a
<b>Means</b>		7.59a	8.05a		10.67a	6.39b	
<b>Calcium (g.kg<sup>-1</sup>)</b>	<b>0</b>	2228.8b	1564.7c	1896.7a	4080.6c	1596.9d	2838.8c
	<b>10+25</b>	3140a	548.4d	1844.2a	7843.8a	1402.8d	4623.3a
	<b>10+50</b>	2744.4a	538.1d	1641.2a	6225.6b	1440d	3832.8b
	<b>10+75</b>	1877.5b c	613.5d	1245.5b	3530c	1024.3d	2277.2d
<b>Means</b>		2497.66 a	816.17b		5420a	1366b	

**Table 7.** The influence of mulching and GA<sub>3</sub>+ Iron mixture (mg.l<sup>-1</sup>) on Seed yield of lettuce *Lactuca sativa* var. longifolia cv. Marul

Parameters/ GA <sub>3</sub> + Iron mixture (mg.l <sup>-1</sup> )	Mulched	Unmulched	Means	
<b>Floret Branch no.</b>	<b>0</b>	17.25b	5.75d	11.5b
	<b>10+25</b>	16bc	8.75d	12.38b
	<b>10+50</b>	15.5bc	10.25d	12.88b
	<b>10+75</b>	31.75a	8.5d	20.13a
<b>Means</b>		20.13a	8.31b	
<b>Weight of 1000 seeds(g)</b>	<b>0</b>	0.76a	0.83a	0.79a
	<b>10+25</b>	0.78a	1.06a	0.92a
	<b>10+50</b>	0.92a	0.75a	0.84a
	<b>10+75</b>	0.77a	0.76a	0.76a
<b>Means</b>		0.81a	0.85a	
<b>Seed yield.Plant<sup>-1</sup>(g)</b>	<b>0</b>	115a	75a	95a
	<b>10+25</b>	95a	78.75a	86.88a
	<b>10+50</b>	75a	108.75a	91.88a
	<b>10+75</b>	126.25a	126.25a	126.25a
<b>Means</b>		102.81a	97.19a	
<b>Seed yield.m<sup>-2</sup>(g)</b>	<b>0</b>	690a	450a	570a
	<b>10+25</b>	570a	472.5a	521.3a
	<b>10+50</b>	450a	652.5a	551.3a
	<b>10+75</b>	757.5a	757.5a	757.5a
<b>Means</b>		616.88a	583.13a	

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