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Effects of Plant Growth Promoting Microorganisms on Yield and Quality Parameters of Lettuce *(Lactuca sativa L.)*

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ABSTRACT

This study was conducted to determine the effects of plant growth promoting microorganisms on yield and some quality attributes of 'Abbice' crisp lettuce variety. Tested treatments were applied via drip irrigation at a dose of 10 ml / L Perla Vita, as water (95%) and molasses (5%) mixture of *Lactobacillus casei* (10^7), *Lactobacillus plantarum* (10^7), *Rhodopseudomonas palustris* (10^5), and *Saccharomyces cervisiae* (10^3)] four times as 1, 2, 3 and 4 weeks after planting the lettuce seedlings. The lettuces in the control did not receive any treatments. Head weight, diameter and height, unmarketable and marketable leaf weight and number, leaf number, root crown diameter, stem length and thickness, and leaf colour (L*, a*, b*) were determined in harvested plants. Treatment with plant growth promoting microorganisms increased head weight and diameter by 7.4% and 6.2%, respectively compared to the control plants. Applications also increased marketable head and leaf weight by 12.0 % and 12.1%, respectively. Unmarketable leaf number and weight were lower (2.8 leaves/head and 11.4 g/head) in treated plants than the untreated lettuces (3.8 leaves/head and 22.3 g/head). Effects of tested microorganisms on other quality parameters showed similarity with control group. The results displayed that plant growth promoting microorganism treatments increases head weight and diameter, marketable head and leaf number whereas decreases unmarketable leaf number and weight.

Keywords: Lettuce, head diameter, head weight, colour.

INTRODUCTION

Salads and lettuce are produced and consumed in large areas in the world as well as in Turkey. According to 2014 datas, world lettuce production was determined as 24 896 116 MT[1]. China is the leading country on production and followed by USA, India and Spain respectively. Turkey's production of total lettuce varieties (Iceberg, crisp and butterhead) in 2016 was 250 556 MT in 553 358 da area [2].

Ecological conditions and cultural practices areclosely related to the optimum growth of lettuces. Plant growth and yield depend on sufficient uptake of plant nutrients [3]. For this reason, an increase is provided on yield and quality via plant nutrients application during the vegetation period. Although chemical inputs increase yield and quality, the excess use causes economical and enviromental damages. Therefore, the soil conservation and productivity maintenance should be well elaborated. Eco-friendly sustainable agricultural practices gain importance year by year. For this reason, the prevalent use of promoting microorganisms has increased [4,5].

Promoting microorganisms with different mechanisms which develop in root zone affect positive the plant growth. These microorganisms affect growth regulators, organic compound production, germination, root development, nutrient uptake, productivity, resistance to stress and diseases [6,7].Promoting microorganisms increase soil fertility, strengthen immunity mechanism of plants and promote healthy development. Efficient microorganism activity transforms plant nutrients into reachable forms during vegetation period. In this way, plant development accelerates [8,9,10,11,12].

Promoting microorganisms increase the uptake of nutrients required for plants through being applied from soil and/or leaf. Promoting microorganisms reduce fixation of unreachable plant nutrients and enable plants to uptake. In this way, the maximum use of plant nutrients is being provided. As a result, promoting microorganisms provide an increase on quality and yield [13]. Eşitken et al. [4], determined that the promoting microorganism mixture with *Pseudomonas* and *Bacillus* increased the yield by 33.2% in organic strawberry cultivation. This increase was related with the rise of P, Fe, Cu and Zn content in plant body and making mineral matters in soil for plants available.

This study was conducted in order to determine the effect of promoting microorganism treatment to the yield and quality of "Abbice" crisp lettuces.

MATERIAL and METHODS

Material

This study was carried out in an open field belonging to Ege University, Faculty of Agriculture, Horticultural Crops Department which located in Bornova/İzmir.

On 27.03.2015, the lettuce seedlings belonging to Abbice variety were planted to an open field as intrarow 30 cm and interrow 70 cm. Study was planned according to complete randomised design as four replicates. Abbice crisp lettuce variety was produced by Syngenta company. It is a productive variety and it has strong, light green and crispy leaves. The production of the variety is convenient for both spring and autumn seasons. Also it is resistant to Bl 16-28,30,31, Nr0, LMV diseases.

Promoting microorganism treatments

The promoting microorganism treatments exposed to lettuce seedlings planted in an open field (Perla Vita, Biosolution Tarım Dan. İth. İhr. Tic. Ltd. Şti.), a)

First application; one week after the planting of lettuce seedlings (03.04.2015), b) Second application; two weeks after the planting of lettuce seedlings (10.04.2015), c) Third application; four weeks after the planting of lettuce seedlings (24.04.2015), d) Fourth application; five weeks after the planting of lettuce seedlings (01.05.2015), were applied four times via drip irrigation at a dose of 10 ml/L. Perla Vita, dissolved in a mixture of water (95%) and molasses (5%); mixture of promoting microorganisms such as *Lactobacillus casei* (107), *Lactobacillus plantarum* (107), *Rhodopseudomonas palustris* (105), and *Saccharomyces cervisiae* (103)]. The number of microorganism was determined as $1.7x10^8$ kob/ml in samples taken from "Perla Vita".

Treatments were subjected to 4 different parcels and each parcel comprised 20 lettuces. 4 other parcels including same number of lettuce without any treatment were accepted as control treatment.

Harvest

Before harvest, several observations were done in both treated and non-treated parcels. Lettuces commercially ready for consumption were harvested on 22.05.2015. In order to represent both treated and non-treated parcels, 10 piece of lettuce were harvested from each parcel. Samples were brought to Physiology Laboratory belonging to Ege University, Faculty of Agriculture, Department of Horticultural Crops.

Yield and Quality Parameters

Head weight: Weights were measured in ±0.05 g digital scale (XB 12100, Presica Instruments Ltd., Switzerland). The average head weight was calculated in terms of g.

Head diameter: Diameter was measured from the widest part through ruler and results were displayed in terms of cm.

Head height: Height was measured by ruler and results were displayed in terms of cm.

Unmarketable leaf number and weight: Unmarketable leaf number was counted one by one from measured lettuce samples and weight (g) was calculated via digital scale.

Marketable head weight: After discarding unmarketable samples, head weight (g) was calculated viadigital scale.

Marketable leaf number and weight: After discarding, remained leaves were counted and weight (g) was calculated via digital scale.

Color: Color was measured from different points of outer leaves through colorimeter (Minolta CR-400, Japan) in terms of CIE L*, a*, b* values. The device was calibrated with standard white calibration plate (L*=97.26, a*=+0.13, b*=+1.71) before measurements. From obtained a* and b* values, chroma and hue angle values were calculated according to these 2 formulations. C* value determines the color saturation (0=mat, 60=saturated). h° value is an angle coordinate in CIE L*a*b* scale (0º= red-purple, 90º=yellow, 180º= bluish green and 270º=blue) [14].

Statistical Analysis

The obtained data was subjected to variance analysis through IBM® SPSS® Statistics 19 (IBM, NY, USA). Standard deviation values of means were calculated over 4 replications with Duncan's multiple range test.

RESULTS

The average head weight, diameter and height of lettuces both treated with promoting microorganisms and non-treated were displayed in Table 1. The effect of treatment was found statistically significant (P<0.05) to head weight and diameter of Abbice lettuce variety. The average head weight of treated lettuces was determined as 325.99 g and this parameter was determined as 303.31 g in control treatment. Obtained data showed that promoting microorganism treatment increased the head weight of lettuces by 7.38% in comparison to control treatment. Promoting microorganism treatment increased the head diameter of lettuces by 6.21% in comparison to control treatment. The effect of promoting microorganism treatment to head weight displayed consistency with effect on head diameter.

The effect of promoting microorganism treatment to head height of lettuces showed similar effects with control treatment. The head height of treated lettuces was determined as 17.35 mm, and in control treatment as 17.23 mm (Table 1).

The alteration on leaf number and weight of unmarketable lettuces according to promoting microorganism treatment was shown in Table 2. The effect of promoting microorganism treatment to discarded leaf number and discarded leaf weight was found significant. Discarded leaf number was determined as 3.84 piece/head) and was found higher in comparison to treated (2.79 piece/head) lettuces. The discarded leaf weight in control treatment was determined as 22.30 g/head and in treated lettuces was 11.35 g/head. Alterations in discarded leaf number and weight were compatible with each other. The promoting microorganism treatment decreased especially the discarded leaf weight in comparison to control treatment.

Marketable head weight, marketable leaf number and weight are important yield and quality parameters in lettuces. Marketable head weight, leaf number and weight of lettuces both in treated and non-treated samples were shown in Table 3. The effect of promoting microorganism treatment to marketable head weight, leaf number and weight was statistically found significant (P<0.01). The marketable head weight of treated lettuces was found as 314.64 g and in control lettuces found as 281.01 g. Results showed that promoting microorganism treatment increased the marketable head weight of lettuces by %11.97 in comparison to control treatment. The leaf number of lettuces in promoting microorganisms treatment was determined as 30.53 piece/head and in control treatment as 28.11 piece/head. The marketable leaf weight of lettuces treated with promoting microorganisms was found 12.13% higher in comparison to non-treated lettuces.

The effect of promoting microorganism treatment on root crown diameter, stem length and weight showed similarity with control treatment. Root crown diameter, stem length and weight of lettuces treated with promoting microorganism were determined as 22.58 mm, 51.13 mm and 23.77 g, respectively. In the control treatment, root crown diameter, stem length and weight of lettuces were determined as 22.85 mm, 50.14 mm and 21.61 g, respectively (Table 4).

L*, a*, b*, C* and h° values of both treated and non-treated lettuces were displayed in Table 5. The effect of promoting microorganism treatment to leaf color (L*, a*, b*, C*, h°) was not found significant and color values showed similarity with control treatment.

DISCUSSION

In Abbice lettuce variety, promoting microorganism treatments increased head weight and diameter in comparison to control treatment by 7.38% and 6.21% respectively.

The head and leaf weight in marketable lettuces treated with promoting microorganisms were found higher 11.97% and 12.13%, respectively in comparison to control

TABLES

Table 1. The effect of promoting microorganism treatment to head weight, diameter and height of lettuces.

Treatments	Head weight (g)	Head diameter(cm)	Head height(cm)
Control	303.31±15.33*	22.46±1.47*	17.23±0.84$^{n.s.}$
Treatment	325.99±22.48	23.85±1.13	17.35±1.44

$^{n.s.}$, not significant; *, significant according to $P \leq 0.05$.

Table 2. The effect of promoting microorganism treatment to discarded leaf number and weight of lettuces.

Treatments	Discarded leaf number (piece/head)	Discarded leaf weight (g/head)
Control	3.84±0.53*	22.30±3.45**
Treatments	2.79±0.29	11.35±2.61

Significant according to *, $P \leq 0.05$ and **, $P \leq 0.01$.

Table 3. The effect of promoting microorganism treatment to marketable head weight, marketable leaf number and weight of lettuces.

Treatments	Marketable head weight (g)	Marketable leaf number (piece/ head)	Marketable leaf weight (g/head)
Control	281.01±15.33**	28.11±1.56$^{n.s.}$	259.40±15.33**
Treatment	314.64±22.48	30.53±1.74	290.87±22.48

$^{n.s.}$, not significant; **, significant according to $P \leq 0.01$.

Table 4. The effect of promoting microorganism treatment to root crown diameter, stem length and stem weight of lettuces.

Treatments	Root crown diameter (mm)	Stem length (mm)	Stem weight (g)
Control	22.85±0.55$^{n.s.}$	50.14±3.69$^{n.s.}$	21.61±0.40$^{n.s.}$
Treatment	22.58±0.78	51.13±3.98	23.77±0.75

$^{n.s.}$, not significant.

Table 5. The effect of promoting microorganism treatment to lettuce color.

Treatments	L*	a*	b*	C*	h°
Control	35.58±1.48$^{n.s.}$	-15.90±0.64$^{n.s.}$	22.12±0.91$^{n.s.}$	33.33±0.22$^{n.s.}$	125.70±0.67$^{n.s.}$
Treatment	35.11±1.19	-15.82±0.54	22.08±0.63	33.46±0.34	121.61±0.58

$^{n.s.}$, not significant.

treatment. The leaf number in lettuces treated with promoting microorganisms was identified as 30.53 leaves/head and in control as 28.11 leaves/head. Previous studies revealed that the effect of promoting microorganism treatments increased the marketable leaf number, wet and dry weight in comparison to non-treated lettuces [15]. Esitken et al. [4], reported that the promoting microorganism treatment increased the yield in organic strawberry cultivation. The antagonistic relation between promoting microorganisms and plants was revealed in previous studies [13,16].

The discarded leaf number and weight in lettuces treated with promoting microorganisms (2.79 leaves/head ve 11.35 g/head) were found lower in comparison to control (3.84 leaves/head ve 22.30 g/head) treatment. The effect of promoting microorganism tretment to other observed quality parameters (leaf color, root crown diameter) showed similarity with control treatment.

Results showed that promoting microorganism treatment increased head weight, head diameter, marketable head and leaf weight in Abbice crisp lettuce variety. Furthermore, same results showed that this treatment decreased discarded leaf number and discarded leaf weight.

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