Iodine Applications in Onion Cultivation

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Abstract— Although iodine is not considered as one of the essential elements in plant nutrition, health problems arise in humans and animals consuming those plants in case of deficiency in plants and trace amounts in plants are beneficial for human health. However, iodine application to plants can have a negative or positive effect on plant growth depending on the species and variety. In this study, the effects of foliar application of iodine on morphological and plant effects and Malondialdehyde (MDA) contents of three onion cultivars grown in nutrient solution were investigated. Foliar iodine applications promoted plant growth in purple and yellow onion, while in white onion, this effect was suppressive in shoots and promotive in roots. MDA levels were higher in white onion where iodine had a suppressive effect on vegetative growth compared to other varieties. It is thought that the suppressive or promotive effect of iodine application on vegetative growth of onion varieties depends on the genotype.

Keywords—Onion Varieties, Foliar Iodine Application, Morphological characteristics, Malondialdehyde.

I. INTRODUCTION

ONION (*Allium cepa* L.) is a product that is widely consumed throughout the world and has a high economic importance. It ranks first in the world in terms of vegetable cultivation area and 10% of the cultivated vegetables are onions. In addition, it ranks second in the world vegetable production and 9.2% of the vegetable production, which is 1.15 billion tonnes according to 2021 data, consists of onions [1]. The phenolic compounds contained in onion consist of many bioactive phytochemicals such as alkenyl cysteine sulphoxides and anthocyanins. The antioxidant properties of flavonoids and sulphur compounds in its content provide biological activities of onion such as antiallergic, antimicrobial, anticarcinogenic. The fact that onion has many different ways of consumption, is accessible to people of all income levels, and has antiseptic and antibiotic properties shows that it is extremely important not only in terms of taste but also in terms of health [2,3].

Plant growth and yield depend on the uptake of macro- and micronutrients by plants. Deficiencies of these elements cause serious problems in the development of plants and these elements are classified as essential elements. The importance of non-essential elements, including iodine, has been revealed by studies carried out in recent years. Iodine is involved in the development of thyroid metabolism and cognitive abilities in humans and in reducing the risk of certain types of cancer [4]. Iodine is one of the least available elements, with only about 3 mg kg-1 iodine is found in soils [5]. In addition to the use of iodised table salts, iodised fertilisation in crop production is one of the methods of iodine supply [6].

Its effect on physiological mechanisms in plants is not yet fully understood. In the model plant Arabidopsis, iodine application at low concentrations increased biomass, provided early flowering and played a functional role in plant nutrition [7]. In addition, positive improvements were determined in biomass increase, antioxidant activity and concentration of elements in pepper [8]. Both positive and negative results in the data obtained from the studies on this subject require detailed studies on the basis of species and dose for iodine applications.

Manuscript received April. 16, 2024.

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II. MATERIAL AND METHODS

The experiment was carried out in November-December 2023, in the experimental greenhouse of Akdeniz University with controlled temperature, humidity and lighting. White, purple and yellow onions obtained from a commercial company were used as plant material. Before planting, the seeds were soaked in water for 24 hours and then planted in pots containing 5 kg substrate.

A substrate mixture of heather soil sieved through a 2 mm sieve and washed peat and perlite in a 1:1:1 ratio by volume was used as growing medium in pots. The physical and chemical analytical characteristics of the potting soil were within the range of acceptable values for vegetable plants (Table 1).

TABLE I THE ANALYTICAL CHARACTERISTICS OF THE POTTING SUBSTRATE

Parameters	
Particle density (g cm^{3-1})	1,57
Total Porosity (%)	84
Organic Matter, %	2,55
Air Capacity (%)	28
pH- H_2O (1:5 w/v)	7.31
EC, dS m^{-1} 25°C	0,89
NO3-N (mg kg^{-1})	47
P (water soluble, mg kg^{-1})	28
K (water soluble, mg kg^{-1})	57

Each pot was considered as one replication and was planned according to the randomized block design with five replications. After the germination of the seeds, thinning was carried out so that 20 plants remained in each pot. Onion plants were grown by fertigation with a nutrient solution which was created by modifying the nutrient solution [9] for vegetable plants (Table 2).

TABLE II
CONTENT OF NUTRIENT SOLUTIONS IN THE EXPERIMENT (mmol 1^{-1})

NO_3^-	$H_2PO_4^-$	SO_4^-	NH_4^+	K^+	Ca^{++}	Mg^{++}	Na^+
13	1.25	1,25	1	7,5	4	1	0,75

The pH value of the nutrient solutions used in the experiment was adjusted to 6-6.5 and the EC value to 2.5 ms.cm-1 (25 C°). Onion plants were fertigated at the rate of 50-200 ml/day with nutrient solutions prepared according to the procedures given above, based on their water consumption and practical leaching of the solution from the pots during the growth period. In order to prevent excessive salt accumulation in the pots, 500 ml of pure water was applied to all pots 1 day a week and then immediately its own solution was applied to drain the accumulated salts. Greenhouse temperature, humidity and illumination were kept at an appropriate level during the rooting and growth stages of the plants.

Foliar iodine application doses were prepared from KI as shown in Table 3 and commercial foliar fertilizer adhesive preparations were added to the Iodien solutions between applications to increase foliar adhesion. The first iodine application was made one month after seed planting, and the second application was made 10 days later.

TABLE III
IODINE LEVELS APPLIED TO ONION PLANTS

Applications	Iodine (KI), µM
1	0 (Control)
2	120
3	140
4	180

Two months later all plants were cut from the surface of the pots and shoot (SL) and root length (RL), shoot fresh (SFW) and dry weight (SDW), root fresh (RFW) and dry weight (RDW) were measured. Malondialdehyde (MDA) analysis was performed to determine whether iodine causes membrane damage [10].

The analysis of variance, correlation between parameters and averages of the findings obtained in the greenhouse experiment carried out according to the random blocks experimental design with 5 replicates was analysed using SPSS software program.

III. RESULTS AND DISSCUSSION

The morphological changes caused by iodine applications in onions are presented in Table 1. The morphological changes caused by iodine applications varied between cultivars. Although I20 application in white onion increased root length, the best plant growth was obtained from the control plant. At the same time, the MDA content increased to the highest level in the I20 µM application (Figure 1). In purple onion it was found that the I20 µM application increased the morphological development of the plants. The longest shoots with 192.38 mm and the highest shoot fresh weight with 0.2933 g were obtained in the I20 µM application. In the other treatments, the vegetative development of the plants lagged behind that of the control plants. In yellow onion, vegetative development of plants was positively affected by I40 application. Shoot length reached 210.70 mm and root length reached 74.45 mm. The highest MDA value was recorded in the I40 µM application.

TABLE IV
CHANGE IN MORPHOLOGICAL CHARACTERISTICS OF ONIONS TREATED WITH IODINE

Onion CultivarS	Treatment	SL	RL	SFW	SDW	RFW	RDW
White	Control	186.16 a	34.47 c	0.2641 a	0.0080	0.1991 a	0.0033
	I20 µM	164.49 b	53.32 a	0.2072 c	0.0054	0.0424 b	0.0019
	I40 µM	161.62 c	43.07 b	0.1499 d	0.0077	0.0286 d	0.0023
	I80 µM	136.76 d	26.63 d	0.2491 b	0.0054	0.0340 c	0.0019
Purple	Control	185.66 b	53.34 a	0.2255 b	0.0148	0.1308 b	0.0043
	I20 µM	192.38 a	53.13 a	0.2933 a	0.0145	0.2389 a	0.0032
	I40 µM	176.24 c	51.88 b	0.2165 c	0.0134	0.1032 c	0.0036
	I80 µM	118.84 d	25.12 c	0.1098 d	0.0146	0.0768 d	0.0027
Yellow	Control	175.14 c	46.57 d	0.1756 d	0.0055	0.0599 a	0.0021
	I20 µM	178.71 b	48.03 c	0.2174 b	0.0058	0.0584 a	0.0016
	I40 µM	210.70 a	74.45 a	0.3295 a	0.0065	0.0585 a	0.0015
	I80 µM	158.85 d	51.61 b	0.1947 c	0.0056	0.0311 b	0.0012
C	2	**	**	ns	**	**	**
T	4	**	**	ns	ns	*	ns
CXT	35	**	**	**	*	**	ns

VS: Variation source, **T:** Treatment, **C:** Cultivar, SL: Shoot length, RL: Root length, SFW: Shoot fresh weight, SDW: Shoot dry weight, RFW: Root fresh weight, RDW: Root dry weight
ns. not significant, * $p < 0.05$, ** $p < 0.01$, Statistical differences between applications are shown with letters, there is no statistical difference between data without lettering.

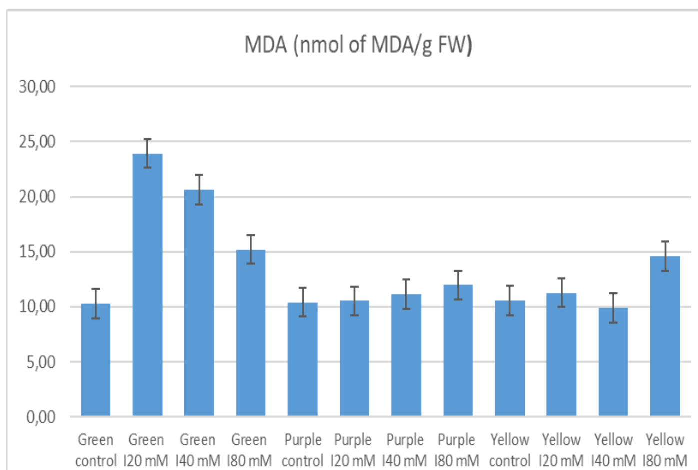
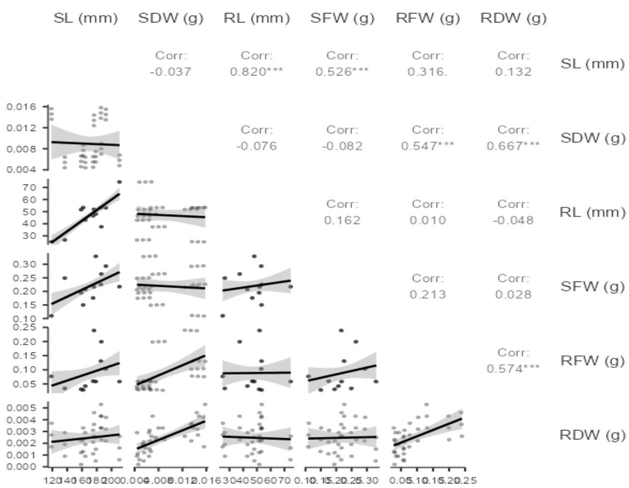


Fig. 1. MDA change according to Iodine applications

The correlation between the morphological characters is shown in Figure 2. According to the statistical analysis, the highest correlation was determined between SL-RL (r = 0.820). It was also found that there were statistically significant positive correlations between SDW-RDW (r=0.667), SDW-RFW (r=0.547), SL-SFW (r=0.526), RFW-RDW (r=0.574).



Although iodine is not considered one of the essential elements, health problems occur in case of deficiency and its presence in trace amounts in plants is beneficial for human health. On the other hand, studies have shown that iodine applied in crop production has a positive effect on plant development [11]. In the current study, the effect of iodine was in the direction of promoting plant growth in purple and yellow onions, while in white onions, this effect was suppressive on shoots and promoting on roots. It is showed that iodine plays a role in plant metabolism [7]. The fact that low doses of iodine applied to the model plant Arabidopsis increased biomass is compatible with the results of the current study. Similarly, low doses of iodine and iodate applied to lettuce increased nitrogen use efficiency and were found to be effective in terms of yield and quality [12].

MDA levels were found to be higher in white onion, where iodine has a suppressive effect on vegetative development, compared to other cultivars. MDA is a product of lipid peroxidation and is considered an indicator of loss of cell integrity, increased cell permeability to electrolytes and impairment of metabolic functions [13, 14]. The high levels of MDA found in white onions explain the regression in plant development.

Iodine application may have a negative or positive effect on plant growth depending on the species and variety. For example, it caused biomass loss in maize [15] and tomato [16], but increased biomass in soya bean and Chinese cabbage [15, 17].

IV. Conclusion

In conclusion, the suppressive or promotive effect of iodine application on the vegetative growth of onions cultivars depends on the genotype. It was found to have a promoting effect on purple and yellow onions and a suppressive effect on white onions.

Acknowledgment

This study was carried out in the research greenhouse and laboratories of the Department of Organic Agriculture, Vocational School of Technical Sciences, Akdeniz University. The authors would like to express their gratitude to the departmental administration and helpful staff.

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