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Effect of calcium and nitrogen spraying on growth, yield and BER disorder of watermelon "Top yield" var. (*Citrullus lanatus*) in Sulaimani Governorate

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Abstract

This study was carried out at Kanipanka Research Station / Sulaymani during growing season of (2015) to study the effect of nitrogen and calcium spraying and their interaction on growth, yield and Blossom-end rot% incidence of watermelon plant ("Top yield" var.).This study included spraying nitrogen as three concentrations (0, 200 and 400 mg N l^{-1}) using urea fertilizer and spraying calcium as four concentrations (0, 100, 300, 600 mg Ca l^{-1}) concentrations using $CaCl_2$. The study's characters were reproductive growth, yield and Blossom-end rot percentage (BER %). The results showed that maximum infected fruits % (32.26 %) was obtained from Ca0. While Ca_3 (600 mg l^{-1}) gave minimum BER infected fruit (6.64 %) and maximum number of flower.plant^{-1} (10.1), yield plant^{-1} (4.98 kg), fruit weight (3.86 kg) and total yield (53.17 t ha^{-1}).N_2 (400mg l^{-1}) gave highest yield plant^{-1} (4.60 kg) and total yield.ha^{-1} (48.11t). Nitrogen and Calcium combination (400mg l^{-1} N x 600mg l^{-1}Ca) gave the highest number of flower plant^{-1} (10.30) and minimum BER% (4.42%). (200mg l^{-1} N x control Ca) gave the highest yield plant^{-1} (5.36kg) and total yield ha^{-1} (55.06t), while (200mg l^{-1} N x 600mg l^{-1}Ca) and (N0 x 600 mg l^{-1}Ca) gave the highest number of fruits plant^{-1} (1.41) and fruit weight (4.02kg), respectively.

Introduction

Watermelon (*Citrullus lanatus* L.) is a herbaceous creeping plant belonging to gourd family (Cucurbitaceae), has been cultivated for thousands of years in the Middle East and South East Asia [1]. Its global consumption is greater than that of any other cucurbit [2]. There are over 1,200 varieties of watermelon worldwide. The fruit ranges in size from 10-100 cm in diameter, mostly round or oblong in shape. The intense red color, spongy formation of the pulp and high water content (about 92 %) of mature fruits make the watermelon most favorite among the consumer [3]. Watermelons are associated with various health benefits; contain vitamin A, B6 and C, lycopene, antioxidants, amino acids and modest amount of potassium. It also serves as a good source of phytochemical and red carotenoid pigment which acts as an antioxidant during normal metabolism and protects against cancer [4]. Production of watermelon has taken important place in agriculture of the world. World production is estimated about 100.6 million tons fruit [5]. Compared to neighbor countries, watermelon production in Kurdistan is low, it may related to many factors include (soil condition, inadequate agricultural guidance for the farmers, shortage of irrigation projects, pathological and physiological problems). There are many physiological disorders which can reduce watermelon production including Hollow heart, Bottleneck, Sunburn and Blossom-end rot [6].Blossom end rot (BER) is a physiological disorder which affects some types of fruits such as watermelons (*Citrullus lanatus*), tomatoes and pepper [7]. BER is related to many factors including inadequate amount of calcium in the blossom of the fruit, high amount of nitrogen, magnesium, salinity and fluctuating in irrigation and moisture amounts [8]. Brantley [9] indicated the effect of calcium and nitrogen fertilizer on watermelon fruit number, the highest total number (186.4) was observed from (Ca 500 × N 180) pounds/acre and the lowest fruit number (92.2) was found in (Ca 0 × N 180) pounds/acre. Goreta *et al.* [10] obtained different watermelon fruit weights (6.87, 6.77 and 6.32 kg/fruit) when (115, 195 and 275 kg.ha^{-1}) nitrogen rates were used, respectively. Audi *et al.* [11] conducted an experiment to study the effect of Calcium Ammonium nitrate (CAN) with different rates (0, 135, 270 and 405 kg N/ha^{-1}) on watermelon yield, and the achieved data were (19.7, 27.5, 34.2 and 36 t.ha^{-1}), consequently.

Since there are little studies on this problem under condition of Sulaimani governorate this investigation was selected. The objective of this study was to evaluate the effects of nitrogen and calcium supply on the incidence of the physiological disorder (Blossom-end rot) and yield of "Top Yield" variety of watermelon.

Materials and Methods

***Location*:** Field experiment was conducted during growing season of 2015 at Knipanka Research Station, 35 km east of Sulaimani city, with GPS reading of 35º 22'25" N, 45º 43'25", E with an altitude (550 m above sea level). The experiment included the study of effect of nitrogen and calcium with different levels on watermelon.

"Top Yield" variety of watermelon was used in this experiment, the standard properties of this grown variety is: "Top Yield" is a seeded watermelon variety, has a green foliage and (1-2 m) vine length. Fruit weight is more than 3 kg, oval shape and its color is light green with light dark stripes. The flesh of this variety is dim red and seeds are small and light dark and 70-100 day was needed to maturity.

Some physical and chemical properties of the study location of soil and metrological data during the study period are shown in the tables (1, 2) respectively.

Table -1: Some physical and chemical properties of the experiment location soil.

Properties	*Sand* $g\ kg^{-1}$	*Silt* $g\ kg^{-1}$	*Clay* gkg^{-1}	*Texture*	*EC* $(dS.m^{-1})$	*pH*	*Total N %*	*Available P* $(mg\ kg^{-1})$	*Soluble* K^{+} $(Meq\ l^{-1})$	*Soluble Ca* $(Meq\ l^{-1})$	$CaCO_3$ $g\ kg^{-1}$
Values	*46*	*532*	*422*	*Silty-Clay*	*0.11*	*7.77*	*0.15*	*8.4*	*0.058*	*1.4*	*185*

Table -2: Some meteorological data of the study location during the study period.

Months (2014-2015)	*Jan. (2015)*	*Feb. (2015)*	*Mar. (2015)*	*Apr. (2015)*	*May. (2015)*	*June (2015)*	*July (2015)*	*Aug. (2015)*
Rainfall (mm)	*70.7*	*99.5*	*62.5*	*4.5*	*11*	…..	…..	…..
Minimum TC^0 (day)	*8*	*10*	*10*	*16*	*29*	*37*	*40*	*38*
Maximum TC^0 (day)	*18*	*22*	*25*	*34*	*40*	*44*	*48*	*45*
Minimum TC^0 (night)	*-6*	*-4*	*-4*	*-1*	*4*	*12*	*17*	*16*
Maximum TC^0 (night)	*3*	*8*	*9*	*8*	*19*	*20*	*28*	*29*

Experiment was designed as a randomized complete block design (RCBD) with (3) replications.

The factorial experiment included 2 factors as follow:

1. Nitrogen factor (0, 200 and 400 mg l^{-1} N) as pure nitrogen
2. Calcium factor (0, 100, 300 and 600 mg l^{-1} Ca)as pure calcium

***Seed sowing and Plowing*:** The field was prepared through plowing by rotary Rotuvator in 13 April and the rows were prepared mechanically with (3 m) length and (1.5) width. Seeds were planted directly in the field on 15 April (2015). Six holes were prepared on one side of the rows with a tool or finger, (2-4) seeds were put in each hole then covered by moist soil and pressed lightly to keep the moisture around the seeds. The first irrigation was applied after planting directly, and after emergence of the seedlings was thinned to a single strong plant per hole. Each plot consisted of a single row by six plants spaced (50 cm) between them giving an area of (0.75 m^2). Standard agricultural practices such as hoeing, weeding and pest controls were carried out during the growing season for all replications, and the chemical fertilizer Triple superphosphate (TSP) was added to the soil once at a rate of 340 kg ha^{-1}.

The field was irrigated by Drip irrigation method as needed by using tensiometer depended on vacuum gauge reading (35) centibar for flowering and fruit setting phase and (40) centibar for vegetative growth phase, which was every (3-4) days. The fruits were harvested 80-95 days after sowing seeds.

Fertilizer application: Foliar application was used at three times. The first application was 20 days after planting on (May 5) (true leaf formation phase), second at the early runner phase on (May 25) (flowering phase) and third when the diameter of fruit was about 5 cm on (June 15) (fruit setting phase).

***Studied parameter*:** Three plants were labeled from each plot and the means were calculated for the following parameters. Vine length (cm), root weight (g), fruit size (cm^3), fruit weight (kg), No. of flowers .$plant^{-1}$, No. of fruits $Plant^{-1}$, Yield $plant^{-1}$(kg), Total yield (t ha^{-1}) and Blossom-end rot (%): Fruits having blossom-end rot were recorded by this equation:

$$\text{Blossom} - \text{end rot (BER \%)} \frac{\text{No. of infected fruits}}{\text{Total number of fruits}} X\ 100$$

***Statistical analysis*:** The results were analyzed statistically and the comparisons among means were carried out by Duncan's multiple range tests (0.05) which analyzed by a computer JMP7 program statistical social science. Values were subjected to square root transformation whenever it was necessary.

Results and Discussions

1. Effect of Calcium

Fruit yields and some parameters related to quality properties are given in table 3. Vine length, root weight and number of fruits. $plant^{-1}$ were not significantly affected by calcium application, while other parameters significantly increased and gave highest fruit size (3731 cm^3), fruit weight (3.86kg), yield $plant^{-1}$ (4.98 kg), total yield(53.17 t ha^{-1}) and minimum fruit infection with BER obtained from calcium (600 mg l^{-1}). Cell wall strength and thickness are increased by calcium addition. Calcium is a critical part of the cell wall that produces strong structural rigidity by forming cross-links within the pectin polysaccharide matrix. With rapid plant growth, the structural integrity of stems that hold flowers and fruit, as well as the quality of the fruit produced, is strongly coupled with calcium availability [12].

Increase in calcium levels caused a decrease in infected fruits with BER, while Ca 600 mg l^{-1} gave 6.46% BER, the other infected fruits were (14.41, 20.51 and 32.26)% obtained from (Ca 300,100 and 0) mg l^{-1}, respectively. BER is a fruit Ca-deficiency and stress-related disorder. The BER symptoms are caused by a separating of the cell membrane and increasing ion permeability [13]. Any factors that increase fruit Ca demand and reduce Ca transport to fruit would increase BER [14]. Therefore, increased calcium seems to be maintaining tissue safety and increasing tissue rigidity [15]. Similar results found by [16], [17] and [18].

Table -3: Effect of calcium on watermelon growth, yield and (BER)%

Ca-levels (mg l^{-1})	Vine length (cm)	Root weight (g)	Fruit size (cm^3)	Fruit weight (kg)	No.of Flower $plant^{-1}$	No. of Fruit $plant^{-1}$	Yield $Plant^{-1}$ (Kg)	Yield (t ha^{-1})	(BER) %
Ca 0	133.16 a	7.71 a	2542 c	2.23 c	9.5 a	1.30 a	3.78 b	39.63 b	32.26 a
Ca 100	124.61 a	7.33 a	2680 c	2.89 b	7.2 b	1.34 a	3.53 b	37.71 b	20.51 b
Ca 300	122.33 a	7.42 a	3243 b	3.11 b	9.2 a	1.27 a	3.71 b	40.11 b	14.41 bc
Ca 600	131.94 a	7.60 a	3731 a	3.86 a	10.1 a	1.37 a	4.98 a	53.17 a	6.46 c

*Numbers within a column carrying the same letters are not significantly different according to Duncan's multiple range tests at 0.05 levels.

2. Effect of Nitrogen

Table (4) demonstrates that nitrogen levels significantly affected on watermelon vine length, root weight, yield and total yield. While, fruit size, fruit weight, number of flowers, number of fruits and BER% were not affected. The highest vine length (167.33 cm) was obtained from (N_{200}) treatment. The differences may be due to the role of N when it is taken up, it forms a major component of chlorophyll, the compound by which plants use sunlight energy to produce sugars from water and carbon dioxide (photosynthesis) It forms a significant component of the nucleic acids such as DNA, the genetic material that allow cells to grow and reproduce, hence growth of the whole plant [19]. This finding agrees with Abdel *et al.*,[20] who observed remarkable increase in vine length with increase in nitrogen application. The observed root weight data (6.78, 6.85, and 8.91) g were obtained from (N_0, N_{100} and N_{200}), respectively. This may be resulted from that hypothesis which explained that the well documented interaction between shoot growth and root growth is based on the complementary functions of shoots and roots. Several hypotheses have been advanced to explain this growth regulation between shoots and roots, and can be classified as having either a functional or a hormonal basis. Functional hypotheses propose that shoot growth is limited by the water or mineral nutrient supply from the roots, and that root growth is limited by the carbon supply from the shoots [21]. Root growth and other characteristics as the rate of growth to depth, root density (root length per soil volume) and maximum rooting depth indicate a supply of potentially available mineral nitrogen and water in subsoil for crops. With increasing nitrogen levels the plant yield increased, the highest yield plant^{-1} (4.60 kg) and total yield (48.11t ha^{-1}) was obtained from (N_{200}). Nitrogen is considered as one of the essential macronutrients required by the plants for their growth, development and yield [22]. Moreover, nitrogen is the main constituent of all amino acids, proteins and lipids that acting as structural compounds of the chloroplast [23]. According to [24], additional increases in nitrogen enhance growth and yield, which can be due to the ability of the plant to take up N that is not necessarily transformed into dry matter and hence growth. Increasing in the yield may be directly or indirectly due to increasing foliage such as leaf number, weight and area. [25] reported similar results on the relationship between watermelon foliage and fruit yield. This could be due to a possible increase in leaf area and weight, carboxylases and chlorophyll content, all of which locate the photosynthetic activity of the leaf and finally dry matter production and distribution to the various organs of plants [26].

Table -4: Effect of Nitrogen on watermelon growth, yield and (BER)%.

N-levels mg l^{-1}	Vine length (cm)	Root weight (g)	Fruit size (cm^3)	Fruit weight (kg)	No .of Flower plant^{-1}	No of Fruit plant^{-1}	Yield Plant^{-1} (Kg)	Yield (t ha^{-1}))	(BER) %
No	97.54 c	6.78 c	3120 a	2.97 a	8.8 a	1.45 a	3.68 b	39.63 b	17.11 a
N100	119.45 b	6.85 b	2990 a	2.97 a	9.0 a	1.30 a	3.73 b	39.82 b	17.80 a
N200	167.33 a	8.91 a	3040 a	3.13 a	9.2 a	1.35 a	4.60 a	48.11 a	20.09 a

*Numbers within a column carrying the same letters are not significantly different according to Duncan's multiple range test at 0.05 level.

3. *Effect of Calcium and Nitrogen interaction*

Table (5) explain that calcium and nitrogen interactions affected yield and it's components. The highest vine length (185 cm), root weight (9.71g), yield plant^{-1} (5.36 kg) and total yield (57.20 t ha) obtained from (N_2 x Ca_0) interaction. Calcium increases ammonium absorption, stimulates photosynthesis, and increases the size of sellable plant parts. It also makes the use of nitrogen more efficient, which improves the economics of production and reduces nitrogen contamination of the environment [27].The largest fruit size (3914 cm^3) and fruit weight (4.02 kg) were obtained from (N_0 x Ca_3), while the highest number of flowers and lowest infection (4.42%) were obtained from (N_2 x Ca_3). This may be due to differences in ionic composition of irrigation water which causes increase in availability of Ca for plant [28] and [29]. Environmental factors that reduce water uptake such as drought, osmotic stress and anoxia reduce Ca fluxes to the shoot and this may be affected root growth [30]. Calcium insufficiency in the fruit may be caused by unsuitable Ca uptake, caused in turn by low concentration in the solution and by antagonism with other cations (K^+ and $NH4^+$) [31].

Nitrogen element has direct and indirect effects on BER infection through affecting on Ca absorption and translocation in the plant. In addition, nitrogen promotes rapid vegetative growth that reduces calcium mobility to the fruit. On the other hand, nitrogen decreases calcium absorption on calcium absorption sites in the roots

[32]. Adding nitrogen in the ammonium form reduces calcium movement and its transmission from the roots to the plants due to an increase in organic acid synthesis rates in the root and consequently block the calcium movement leading to decline it's concentration then occurrence of BER [33]. [34] Suggested that nitrogen nutrition in ammonia form has an effect on plant water potential and this affect calcium absorption and distribution and occurrence physiological disorders such as BER appearance.

Table -5: Effect of (Nitrogen X Calcium) interactions on watermelon growth, yield and (BER) %.

N × Ca	Vine length (cm)	Root weight (g)	Fruit size (cm^3)	Fruit weight (kg)	No. of Flower $plant^{-1}$	No. of Fruit $plant^{-1}$	Yield $Plant^{-1}$ (kg)	Yield ($t\ ha^{-1}$)	(BER) %
N0 × Ca0	97.83 de	6.42 d	2710 c-f	2.15 f	10.1 a	1.21 a-c	3.26 de	34.78 d-e	30.19 ab
N0 × Ca1	98.16 de	6.46 d	2530 ef	2.95 cd	6.1 b	1.13 b-c	3.34 de	35.67 d-e	19.95 a-d
N0 × Ca2	95.00 e	6.93 d	3330 a-c	3.40 bc	8.8 ab	1.13 b-c	3.72 cd	41.22 cd	11.20 de
N0 × Ca3	99.16 de	7.31 cd	3910 a	4.02 a	10.1 a	1.16 a-c	4.39 bc	46.83 bc	7.11 de
N1 × Ca0	116.66 c-e	6.99 d	2610 d-f	2.35 ef	9.1 a	1.19 a-c	2.72 ef	29.06 e	32.43 a
N1 × Ca1	118.33 cd	6.60 d	2500 e-f	2.90 c-e	8.0 ab	1.27 a-c	3.50 de	37.37 c-e	14.76 c-e
N1 × Ca2	111.33 e-e	6.88 d	3230 b-d	2.92 cd	9.0 ab	1.08 c	3.35 de	35.89 de	16.14 b-e
N1 × Ca3	131.50 c	7.14 d	3610 ab	3.71 ab	9.8 a	1.41 a	5.35 a	57.05 a	7.86 de
N2 × Ca0	185.00 a	9.71 a	2300 f	2.18 f	9.1 a	1.16 b-c	5.36 a	57.20 a	34.05 a
N2 × Ca1	157.33 b	8.92 ab	3030 b-e	2.82 de	7.6 ab	1.32 a-c	3.75 cd	40.08 cd	26.82 a-c
N2 × Ca2	160.66 b	8.64 b	3160 b-e	3.00 cd	10.0 a	1.35 ab	4.06 cd	43.30 cd	15.07 c-e
N2 × Ca3	165.16 ab	8.36 bc	3687 ab	3.86 ab	10.3 a	1.38 a-b	5.21 ab	55.61 ab	4.42 e

*Numbers within a column carrying the same letters are not significantly different according to Duncan's multiple range test at 0.05 level.

Conclusions: According to the results obtained from this study, the following conclusions could be drawn:

Blossom-end rot (BER) is a physiological disorder influenced strongly by calcium deficit, so highest infection% was obtained from zero calcium treatment, while the lowest infection% obtained from 600 mg l^{-1} calcium. The highest number of flower, fruit size, fruit weight, yield and total yield per hectare of watermelon obtained from 600 mg l^{-1} calcium. Adding nitrogen at high levels resulted in an increase in vine length, root weight and yield.

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