THE ROLE OF SPRAYING NITROGEN ON GROWTH AND NUTRITIONAL VALUE OF FRUITS IN DIFFERENT TOMATO GENOTYPES

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ABSTRACT
An experiment was conducted at the field of the Department of Horticulture and Landscape Gardening, College of Agriculture, University of Baghdad during the spring season of 2012 to evaluate Nitrogen (Urea) foliar application at four concentrations 0 , 1.5 , 3 , and 4.5 g/L^{-1} and six tomato genotypes ,OLKA , JINAN, SUN, GS12, BAHGAT (*Lycopersicon esculentum* Mill) and wild type (*Lycopersicon pimpinillifolium)*. The experiment was carried out according to the split–plot experimental design with three replications in order to determine the best concentration of urea along with the best genotype(s) respond to the treatments. Results showed Spraying with 4.5 g. L^{-1} (Urea) gave significant response in terms of number of main branches (4.98 branch. Plant $^{-1}$), leaf area (229.11 $decm^2$.$Plant^{-1}$), total chlorophyll (261.86 mg. $100g^{-1}$ fresh weight), early flowering (27.83 day), acidity, T.S.S. and nitrogen in fruits (0.23, 4.01 and 2.26%, respectively). The Interaction of the same concentration with GS12 gave the best average of total chlorophyll and T.S.S. of (306.22 mg. $100g^{-1}$ fresh weight and 4.70% respectively) in addition to early flowering and fruit set of (25.33 and 31.67 day respectively).

Key word: Foliar application, Nitrogen, acidity, chlorophyll, flowering, *Lycopersicon esculentum* Mill, *Lycopersicon pimpinillifolium*

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دور الرش بالنتروجين في النمو والقيمة الغذائية لثمار تراكيب وراثية مختلفة من الطماطة

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المستخلص
اجريت تجربة في الحقل المكشوف التابع لقسم البستنة وهندسة الحدائق – كلية الزراعة جامعة بغداد خلال الموسم الربيعي 2012 لتقييم رش اربعة تراكيز من اليوريا 0، 1.5 . 3 . 4.5 غم / لتر على نباتات ستة تراكيب وراثية من الطماطة هي: OLKA , JINAN, SUN, GS12, BAHGAT (*Lycopersicon esculentum* Mill) and wild type, (*Lycopersicon pimpinillifolium)*. نفذت النجرية وفق تصميم الالواح المنشقة وبثلاث مكررات بهدف تحديد افضل تركيز من اليوريا وافضل تركيب وراثي يستجيب لمعاملات الرش. أظهرت نتائج الدراسة تفوق معاملة رش اليوريا بتركيز 4.5 غم . لتر$^{-1}$ معنوياً في عدد الأفرع الرئيسة (4.98 فرع) و المساحة الورقية (229.11 دسم^2.نبات$^{-1}$) والكلوروفيل الكلي (261.86 ملغم100 غم وزن طري$^{-1}$) والتبكير بالتزهير (27.83 يومًا) و النسبة المئوية لكل من الحموضة والمواد الصلبة الذائبة الكلية والنتروجين في الثمار(0.23 و 4.01 و 2.26 % على الترتيب). ادى التداخل معاملة الرش باليوريا بالتركيز ذاته التركيب الوراثي جي اس 12 الى اعطاء اعلى قيمة للكلوروفيل الكلي والنسبة المئوية للمواد الصلبة الذائبة (306.22 ملغم.100 غم وزن طازج$^{-1}$ و 4.70% على الترتيب) بالاضافة الى التبكير بالتزهير والعقد (25.33 و 31.67 يوم على الترتيب).

كلمات مفتاحية: التسميد الورقي، نتروجين، الحموضـــة، الكلوروفـــيل، التزهيـــر، *Lycopersicon esculentum* Mill، *Lycopersicon pimpinillifolium*.

***البحث مستل من رسالة ماجستير للباحث الثاني.**

INTRODUCTION

The interest in tomato's fruit quality has increased nowadays due to its high content of nutrients that impact heavily on health along with its antioxidant property which snuffs out cancer-causing trace radicals within mammalian system (30). Economically, tomatoes considered to be among the top ten crops with an emphasis on fruit quality that determined by its content of organic acids and sugars which significantly influence fruits flavor and therefore determine the use of these fruit either for processing or fresh consumption. It is considered to be a good source of vitamin A and C and help to alleviate the deficiency of these vitamins in many developing countries (12 and 27). Fruit quality trait of tomato is complex and depends on several factors (26). However, crop management can be considered the most important especially when it comes to fertilization where fruit quality is significantly affected by the amount and form of nitrogen applied (11; 15; 19 and 29). The improvement of growth may be a result from improving nutritional status of the plant by providing quick and easy nutrients, including nitrogen which is one of the major nutrients important for plant due to its involvement in the composition of amino acids, nucleic acids, and enzymes, in addition to playing an important role in chlorophyll synthesis (6 and 4). Nitrogen deficiency symptoms are clearly exhibited on plant growth and can be overcome with the appropriate application of nitrogen-released fertilizers through either soil or foliar application. However, foliar application is 8 – 20 times more efficient in suppling nitrogen to the plant when compared with soil application depending on several criteria including crop nature, form of fertilizer added, concentration of active elements, and application frequency and Timing (20). Tomato genotypes vary in their responsiveness to nitrogen fertilizer (10). Hence, it is crucial to choose the appropriate genotypes that correspond with the type and method of fertilizer applied to achieve the ultimate result in term of productivity. Therefore, the aim of this study was to determine the effect of nitrogen foliar application (as urea) on different genotypes of tomato plants under open field condition on growth and nutritional value of fruit.

MATERIALS AND METHODS

The experiment was carried out at the vegetable field of the Department of Horticulture and Landscape Gardening, Collage of Agriculture, University of Baghdad during the spring season of 2012. Nitrogen application was at four concentrations of aqueous urea (0 ; 1.5 ; 3 and 4.5 g/L) Symbolized as N0, N1, N2, N3, respectively, used on six tomato genotypes, Five hybrids of which belong to *Solanum lycopersicon* Mill (Jinan, Olka, Bahjat, Sun, and GS12) plus one wild type variety *Solanum pimpinellifolium*. Seeds were sown on the 23rd of January, 2012 in seedling trays and placed in unheated green house. Urea foliar application with previously mentioned concentrations was initiated a month after seed planting followed by five other applications, two weeks apart, started from the date of replanting the seedlings in the open field which was on the 1st of April, 2012. Last application was on the 3rd of June, 2012. Seedlings were planted in the open field on both sides of the bench spaced 4.5 m length, 1.5 m width, and 40 cm as interplant distance. Other required fertilizers were also applied after two weeks of planting according to (2). A factorial experiment in split plot design with three replications was applied where aqueous urea applications were randomly distributed in main plot using the randomized complete block design (RCBD) and the genotypes were randomly distributed in sub plot. Data were analyzed using the least significant difference (LSD) for comparison at %5 level of significance (5). A random sample of five plants from each experimental unit was taken at the end of the season and used as indicators of vegetative growth, flowering, and productivity. In addition, a random sample of ten fruits was taken at ripening stage to measure degree of hardness, acidity, total soluble solids (T.S.S.), vitamin C, and Nitrogen in fruits (25).

RESULT AND DISCUSSION

Vegetative Growth Traits: Results in table (1) showed a significant response of tomato plants to aqueous urea application presented in increasing the number of branches and leaf area where N3 gave the most significant increase of (4.96 branch.plant^{-1}and 229.11decm^{2}.plant^{-1}, respectively) compared to N0 (2.83 branch.plant^{-1} and 47.23 decm^{2}.plant^{-1}, respectively). This can be attributed to the impact of nitrogen on the levels of cytokinine within the plant as it was suggested that cytokinine increased with increasing concentration of nitrogen fertilizer which correspondingly reduce the effect of apical dominance and therefore encourages the growth of side shoots (28). In addition, nitrogen has an important role in increasing cell count and size (14). Nevertheless, Results in table (1) indicated that wild-type plants gave the most significant values in term of no. of branches and leaf area which recorded (7.49 branch.plant-1 and 191.22 decm2.plant-1, respectively). In addition, hybrid tomato genotypes under investigation significantly differ in term of no. of branches where GS12 gave the highest value of (3.50 branch.plant-1) compared with the lowest value of (3.10 branch.plant-1) in SUN hybrid. On the other hand, the interaction between genotypes and N concentrations applied showed to have a significant effect on both no. of branches and leaf area where N3 with tomato wild type gave the most significant value in both parameters of (10.63 branch.plant-1 and 278.9 decm2.plant-1, respectively) while N0 with BAHJAT gave the lowest value in no. of branches which was (2.26 branch.plant-1) and for leaf area in JINAN of (38.20 decm2.plant-1). Nitrogen foliar application showed to have a significant impact on chlorophyll content as presented in table (1) where N3 gave the highest value the scored (261.86 mg.100g-1 fresh weight) compared with N0 which gave the lowest value of (202.04 mg.100g-1 fresh weight). Our findings came in consistent with(1; 8 and 31) which suggested that a steady increase in nitrogen application lead to increase chlorophyll content in plant leaves. GS12 gave the highest value in term of chlorophyll content (263.55 mg.100g-1 fresh weight) but did not significantly differ from OLKA (260.62 mg.100g-1 fresh weight) while the lowest value was obtained from the wild-type which was (211.28 mg.100g-1 fresh weight). As for the interaction, results in table (1) showed that GS12 with N3 gave the most significant value of chlorophyll content of (306.22 mg.100g-1 fresh weight) while the lowest value was obtained from the wild-type with N0 of (184.06 mg.100g-1 fresh weight).

Flowering and fruits set:

Flowering in tomato is a genetically-controlled trait which varies among genotypes; however, it can be influenced by other external factors that control vegetative growth which, if exacerbate, will affect plant signaling toward early flowering (9). This might be economically beneficial especially if the crop financial value is increased by early production. Results in table(2) showed that an increase in nitrogen concentration applied (N3) reduced the number of days from planting to flowering which recorded (27.83 days) when compared with N0 that gave (30.22 days). This result was in agreement with the findings of (16 and 22) where they found that nitrogen fertilization had encourage early flowering of tomato only if added in the appropriate concentrations within certain plant growth stages. The reason can be attributed to the role of nitrogen energy-rich compounds that increase carbohydrates production which lead to increase vegetative growth (Table 1) and promote for early flowering. Results in the table (2) indicate that wild-type and GS12 did not significantly differ in term of early flowering (26.75 and 26.83 days, respectively) but showed a significant reduction in number of days to flowering when compared with OLKA and JINAN that gave (29.00 and 30.92 days, respectively). The hybrid GS12 treated with N3 showed the most reduction in number of days to flowering which gave (25.33 days) while JINAN hybrid treated with (N0) gave the highest number of days to flowering and scored (34.00 days). High temperature and nutritional status are part of many other environmental factors which contribute to the flower-to-fruit developmental process (13). The results presented in the table (2) exhibited that nitrogen levels did not have significant effect on reducing the number of days from planting to fruit set in 50% of the plants under investigation. Nonetheless, genotypes showed to have much significant effect on such manner where wild-type plants proved to have the lowest number of days to fruit set (32.75 days) with no significant differences when compared with GS-12 that gave (34.00 days).

Interaction between genotypes and nitrogen concentrations used showed that GS-12 gave the most significant response in term of number of days to fruit set when treated with (N3) of (31.67 days) while SUN genotype gave the highest number of days to fruit set when treated with (N0) of (42.67 days).

Quality Fruits Traits:

Nitrogen accumulation in plant body is a natural phenomenon occurred as a result of an increased concentration of nitrogen in the soil (17). The increased use of chemical fertilizers substantially increased nitrogen ratio within the plant which may cause adverse consequences to human health and the environment (21 and 23). Results in table (2) indicated exponential increase in nitrogen ration within tomato fruit as a result of increased nitrogen concentrations applied when (N3) gave 2.26% nitrogen.fruit^{-1} compared to (N0) that gave 0.87% nitrogen.fruit^{-1}. The reason may be due to that most of the plants including tomato can absorb urea as a source of nitrogen through the spray-on shoot application (24) where it can transmitted to the fruit through two different routes: directly through fruit's exoderms and indirectly by leaves through either the source-to-sink process or other biological means including respiration and water flow. Results indicated that OLKA gave the highest nitrogen percentage in fruit tissues that reached (1.79%) though it did not significantly differ than GS12 (1.77%) and BAHGAT (1.76%) while the wild type plants gave the lowest nitrogen percentage in fruit which reached (0.98%). These differences can be consoled to the differences in plant genomes that affect the biological processes including absorption and metabolism where most of these processes are controlled by considerable number of genes (7). As presented in table (2), GS12 treated with N3 gave the highest nitrogen percentage in fruits which scored (2.99%) in comparison with JINAN hybrid treated with (N0) which gave the lowest percentage of nitrogen in fruits of (0.40%). Results in table (3) showed a significant effect of foliar application of urea on the firmness of tomato fruits where increasing the concentration of nitrogen to N2 or N3 led to a significant reduction in fruit firmness which gave (3.33 and 3.24 kg/cm^2, respectively) with no significant differences when compared to the control treatment (N0) that gave (3.71 kg/cm^2) while a significant reduction was observed in wild type plants that gave (2.84 kg/cm^2). Our results came in agreement with the findings of (8) that increasing nitrogen applied concentrations will reduce the firmness of tomato fruits. This reduction in fruit hardness correlated with the increase in nitrogen applied concentration can be explained by the role of nitrogen in the biosynthesis of plant hormone including ethylene along with many plant enzymes including protopectinase that responsible for decomposing pectin materials (13) and lower fruit hardness in result. Results in table (3) showed that increasing nitrogen concentrations applied significantly reduce fruit content of vitamin C where (N2) and (N3) gave the lowest values of vitamin C content in tomato fruit which were (14.12 and 13.33 mg. 100 g^{-1}, respectively) with no significant difference when compared to (N0) that gave the highest content of vitamin C in fruits of (17.18 mg. 100 g^{-1} fresh weight). This reduction in vitamin C content can be due to the shading generated by the increase in vegetative growth as vitamin C increased in bright light condition and reduced under low light condition (13). As presented in table (3), no significant differences were observed among genotypes under investigation in term of vitamin C content in the fruit but were all differed significantly when compared with the wild type. In table (3), JINAN gave the highest content of vitamin C (16.26 mg. 100 g^{-1} fresh weight) while wild-type plants gave the lowest content of vitamin C (12.90 mg. 100 g^{-1} fresh weight). It is noted from the results in table (3) that interaction between genotypes and treatment applied had a significant effect on vitamin C content in tomato fruits where GS12 treated with (N0) gave the highest vitamin C content of (20.96 mg. 100 g^{-1} fresh weight) compared with the lowest value when wild type plants treated with (N3) that gave (9.69 mg. 100 g^{-1} fresh weight). In addition, results in the table (3) indicated a significant increase of fruit acidity when using (N3) application in comparison with other treatments which gave (0.23%) while (N0) treatment gave the lowest value of fruit acidity of (0.17%). Increasing in photosynthetic products as a result of urea foliar application might be the reason of the clear elevation of fruit acidity where organic acids production substantially increased as nitrogen concentration increased. OLKA hybrid gave the highest percentage value of fruit acidity of (0.26%) followed by BAHGAT (0.21%) and GS12 (0.20%) while the lowest percentage value of fruit acidity was observed in the fruits of wild-type plants which was (0.16%). Results in table (3) showed a significant effect of the interaction between genotypes and nitrogen treatments applied in term of fruit acidity where OLKA treated with (N1) and (N3) in addition to BAHGAT treated with (N2) gave similar acidity percentage of (0.32%) while JINAN treated with (N2) and wild type plants treated with (N0) gave the lowest percentage of fruit acidity which was (0.14%). Percentage of total soluble solids (TSS) is one of the valuable quality traits which indicate an increase in the nutritional value of fruits and increase storage ability (7). Fruit's total soluble solids is economically important parameter which determine if the fruits and suitable for processing. Fruit's content of TSS is influenced by a number of factors including genetics, growing environment, and management practices (13). Results in table (3) clearly exhibited a significant differences due to urea foliar application where (N3) gave the highest rate of TSS of (4.01%) compared to (N0) which gave the lowest rate of TSS of (3.70%). This can be explained by the gradual increase in leaf area as a result of increasing nitrogen concentrations applied which, therefore, increasing plant metabolites including minerals, soluble sugars, and organic acids and finally increasing TSS. As presented in table (3), wild type plants gave the highest percentage of TSS which was (4.21%) followed by JINAN and BAHGAT that yield (3.96 and 3.87%, respectively) with no significant differences among each other while OLKA gave the lowest TSS percentage of (3.49%). The Results indicated the presence of significant differences due to the interactions between genotypes and nitrogen concentrations applied where GS12 treated with (N3) gave the highest TSS percentage of (4.70%) while GS12 treated with (N0) gave the lowest TSS percentage of (3.30%). The reason may be due to the nature of interaction between genotypes and the environmental conditions. From what have been mentioned above, we concluded that the applied nitrogen concentrations resulted in different response for all traits under investigation with clear differences among tested genotypes. Therefore, we recommend using 4.5 g of urea. Liter $^{-1}$ as a best nitrogen concentration especially when used with GS12 hybrid under open field condition in order to obtain a better fruit quality for processing or fresh consumption.

Table 1. Effect of Spraying with Urea and genotypes and there interaction for Vegetative Traits of tomatoes in spring 2012.

Conc. Of Urea (g.l^{-1}) → / Genotypes ↓	No. of branch (branch.plant^{-1})					Leaf area (dcm^2.plant^{-1})					Chlorophyll (mg.100g^{-1} fresh weight)				
	N0	N1	N2	N3	Mean of Genotypes	N0	N1	N2	N3	Mean of Genotypes	N0	N1	N2	N3	Mean of Genotypes
OLKA	2.46	3.06	3.60	3.53	3.36	57.3	70.4	152.9	254.8	133.85	213.06	245.58	284.84	299.0	260.62
JINAN	2.70	3.56	3.73	3.90	3.47	38.2	49.2	78.7	219.4	96.37	194.69	206.23	229.19	137.03	216.79
SUN	2.33	3.40	3.66	3.20	3.10	47.9	55.8	70.1	172.4	86.55	201.17	214.33	227.25	257.71	225.12
GS12	3.53	3.20	4.10	4.36	3.50	40.3	77.6	218.5	243.6	146	227.26	240.36	280.32	306.22	263.55
BAHJAT	2.26	3.10	3.40	4.03	3.20	40.3	70.4	188.2	205.6	126.16	192.02	207.51	219.55	231.6	212.67
Wild type	4.70	5.60	8.93	10.63	7.49	59.4	191.9	234.7	278.9	191.22	184.06	204.1	217.41	239.59	211.28
L.S.D. 5%	0.14					53.92					43.62				
Means of conc.	2.83	3.56	4.57	4.96	0.19	47.23	85.88	157.18	229.11	28.17	202.04	219.68	243.09	261.86	32.08
L.S.D. 5%	0.24					20.4					29.74				

Table 2. Effect of Spraying with Urea and genotypes and there interaction for flowering and fruits set and Nitrogen in fruits of tomatoes in spring 2012.

Conc. Of Urea ($g.l^{-1}$) →	No. of days to flowering					No. of days to fruits set					N % in fruits				
Genotypes ↓	N0	N1	N2	N3	Mean of Genotypes	N0	N1	N2	N3	Mean of Genotypes	N0	N1	N2	N3	Mean of Genotypes
OLKA	29.67	29.00	30.33	27.00	29.00	36.67	35.67	36.00	36.00	35.54	1.88	1.59	1.72	1.96	1.79
JINAN	34.00	30.67	30.67	28.33	30.92	36.67	36.00	37.00	37.33	38.66	0.40	0.94	1.03	1.96	1.08
SUN	31.00	33.00	32.67	30.33	31.75	42.67	39.00	35.67	38.44	38.91	0.86	1.03	1.65	2.45	1.50
GS12	27.33	28.00	27.67	25.33	26.83	33.33	33.33	32.00	31.67	34.00	0.77	1.18	2.14	2.99	1.77
BAHJAT	32.67	31.67	32.00	29.33	31.42	40.00	37.00	39.33	36.00	36.33	0.84	1.62	2.13	2.46	1.76
Wild type	26.67	28.00	25.67	26.67	26.75	32.00	34.00	30.00	32.00	32.75	0.47	0.76	0.97	1.73	0.98
L.S.D. 5%	2.30					3.98					0.59				
Means of conc.	30.22	30.06	29.28	27.83	1.09	36.89	35.83	35.00	35.22	1.99	0.89	1.19	1.61	2.26	0.29
L.S.D. 5%	1.58					N.S					0.31				

Table 3. Effect of Spraying with Urea and genotypes and there interaction for quality Traits of tomato fruits in spring 2012.

	Degree of hardness (kg.cm$^{2-1}$)					Vitamin C (mg.100g^{-1} fresh weight)				
Conc. Of Urea (g.l^{-1}) → Genotypes ↓	N0	N1	N2	N3	Mean of Genotypes	N0	N1	N2	N3	Mean of Genotypes
OLKA	2.94	3.55	3.38	2.99	3.21	14.67	17.96	10.91	17.18	15.18
JINAN	4.56	4.24	3.38	4.28	4.11	20.61	13.84	17.02	13.56	16.26
SUN	5.04	4.58	3.76	3.57	4.24	14.66	15.79	17.42	11.55	14.85
GS12	3.62	3.30	3.47	3.81	3.55	20.96	19.85	10.43	13.61	16.21
BAHJAT	3.53	3.29	2.63	2.55	3.00	16.52	18.55	15.40	14.37	16.21
Wild type	2.57	3.19	3.38	2.22	2.84	15.65	12.76	13.51	9.69	12.90
L.S.D. 5%	0.28					3.72				
Means of conc.	3.71	3.69	3.33	3.24	0.17	17.18	16.46	14.12	13.33	1.72
L.S.D. 5%	0.11					1.61				
Genotypes ↓	Acidity %					T.S.S. %				
OLKA	0.21	0.32	0.21	0.32	0.26	3.50	3.35	3.63	3.54	3.49
JINAN	0.17	0.15	0.14	0.22	0.17	4.00	3.60	4.00	4.23	3.96
SUN	0.21	0.19	0.16	0.16	0.18	3.70	3.57	3.53	4.03	3.71
GS12	0.15	0.14	0.21	0.31	0.20	3.30	3.40	3.43	4.70	3.73
BAHJAT	0.17	0.15	0.32	0.20	0.21	3.73	4.41	3.97	3.40	3.87
Wild type	0.14	0.15	0.18	0.20	0.16	4.00	4.40	4.30	4.17	4.21
L.S.D. 5%	0.04					0.21				
Means of conc.	0.17	0,18	0.20	0.23	0.02	3.70	3.78	3.81	4.01	0.11
L.S.D. 5%	0.01					0.10				

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