Effect of Pozzolan and Nitrogen Fertilizer in Reducing Irrigation Water and Soil Moisture Stress in Three Eggplant Cultivars (*solanum melongina*)

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Abstract. Two field experiments were carried out during 2009 and 2010 seasons to study the effects of pozzolan, nitrogen fertilization levels, (50, 75, 100, and 125 kg N/ha) and four irrigation intervals (2, 4, 6, and 8 days) on fruit yield, yield components and chemical proprieties of 3 eggplant cultivars (black beauty, long purple and top bell) in a split split split plot design with three replications. The results indicated that pozzolan treatment significantly increased plant height, leaf area/ plant, no. of fruits/plant and fruit yield/ha besides total soluble solids (TSS) and vitamin C in fruit compared with the pare land (without pozzolan). Increasing irrigation interval significantly reduced plant height, leaf area/plant, no. of fruits /plant, fruit yield/ha and increased TSS, and Vitamin C in fruits. As nitrogen fertilizer increased, plant height, leaf area, no. of fruits/plant and fruit yield/ha significantly increased also TSS, and Vitamin C in fruits increased. Eggplant cultivars significantly varied in their response to pozzolan, irrigation interval and nitrogen fertilizer treatments. Black beauty cultivar significantly dominated the other cultivars in fruit yield/ ha.

Keywords: Eggplant, pozolan, nitrogen, Irrigation, Moisture stress.

Introduction

The supply of water for use in agriculture is becoming increasingly limited. Drip irrigation reduces moisture loss through evaporation and run-off, but even this conservation practice may not be adequated in dry years. Vegetable crop production in arid region is particularly sensitive to

deficiencies of soil moisture (Thompson and Doerge, 1995). Use of rock mulch is very common in different regions to reduce evaporation. (Chesworth *et al.*, 1983 and Fernandez and Salguero, 1987).

Mulches reduce moisture losses through evaporation and other positive effect on soil productivities and accordingly improvement of plant vigor as well as their seedlings (Groenevelt *et al.*, 1989; Ossom *et al.*, 2001; Diaz-Perez *et al.*, 2004; Raemarkrishana, 2006; Kittas *et al.*, 2006; Moreno and Moreno, 2008; and Dong *et al.*, 2007, 2008,2009).

High nitrogen fertilizer treatments during propagation produced more rapid vegetative growth and increased yield of vegetable crops (Du *et al.*, 1989; Allan, 1989; Khalttack *et al.*, 2001; and Sainju *et al.*, 2002). Increasing in discharge rate and vertical and horizontal water movement in pozzolan land compared to berlite, and particle size has an effect on moisture distribution (Shahin *et al.*, (1999). Addition of pozzolan to the soil has resulted in a reduction of irrigation water consumption and to an increase in the growth of crops and yield (Karama and Brohi, 1995 and Shanging and Unger, 2001). Buerkert *et al.* (2000) in experiments lasted for 4 years found an increase in dry weight of millet, sorghum and corn due to covering soil with field crops straw. McIntyre *et al.* (2000) found an increase in the biomass production in the agriculture soil covered with mulch three times that produced by uncovered soil. Covering agriculture soil with mulch straw or animal manure is accompanied with increase in plant height, crop production and biomass (Badaruddin *et al.*, 1999).

The Objectives of this research were: (a) Using soil mulch to decrease the water consumption, (b) Using nitrogen fertilizer to increase yield and growth of 3 eggplant cultivars under different water stress treatments.

Materials and Methods

Two field experiments were conducted during 2009 and 2010 seasons at Agriculture Research Station, King Abdulaziz University at Hada Alsham to study the effect of Pozzolan as soil mulch, nitrogen fertilization rates (50, 75, 100 and 125 kg N/ha) and 4 irrigation intervals (2, 4, 6 and 8 days) on yield and yield components of three eggplant cultivars (Black beauty, Top bell and long purple). Main treatments were 2 soil mulches, sub plot treatments were 4 irrigation intervals, and the 4

nitrogen fertilization rates were located sub sub plots, while 3 eggplants cultivar were the sub sub sub plot treatment.

A split split split plot design with three replications was used. The sub sub sub plot size was 2x3 m and the experiments were designed according to El-Nakhlawy (2010).

The experimental site soil analysis was done before planting. Soil was characterized with 7.84 as a soil pH, 2.33 DSm⁻¹ as soil electrical conductivity (EC), 0.57% organic matters, 0.6% nitrogen (N), 0.03% phosphorus (P) and 0.008% potassium (K). Soil consisted from 82% sand, 15% silt and 3% clay. The soil texture was Sand loam.

Land was prepared for planting and pozzolan (5 cm) was spread. Phosphorus and potassium fertilizers were added before spreading the pozzolan on the soil with 100 kg P₂O₅/ha and 100kg K₂O/ha. nitrogen fertilizer (Urea) was applied with four rates (50, 75, 100 and 125 Kg N/ha). Seeds were sown in mid of August and transplanted in mid of September. Drip irrigation network was used. At harvest, 10 random plants in each sub sub sub plot were used to determine plant height (cm), leaf area/5 plants, no of fruits/plant, fruit yield (kg/ha). Fruit yield/ha was determined as converted from the fruit yield/plot. Also chemical characteristics of total soluble solid (T.S.S) and vitamin C. of the fruit were determined.

Statistical Analysis

The obtained data of the studied factors were statistically analyzed of using analysis of variance procedures and the resulted means of the significance factor or the interaction were statistically compared with LSD at $P \leq 0.05$ according to El-Nakhlawy (2010).

Results and Discussion

Significant differences were found among eggplant cultivars as regards plant height, and leaf area/5 plants (cm³), no. of fruits/plant, fruit yield, total soluble solid (T.S.S), and vitamin C content in eggplant fruits due to the effect of pozzolan, irrigation treatment and nitrogen fertilizer rates during 2009 and 2010 seasons.

1- Effect of Pozzolan

Pozzolan increased all traits over control treatment (no Pozzolan), plant height from 54.8 to 61.81 cm, leaf area / 5 plants from 2752.14 to 2901.39 cm², no of fruits/ plant from 19.48 to 28.02, and fruit yield from 22217.68 to 25531.9 kg /ha. during the first season 2009.

While Pozzolan treatment decreased TSS from 2.55 to 2.82 and 3.25 to 2.63, and vitamin C content (from 5.4 to 4.62, and from 5.01 to 4.27 in egg plant fruits under 0 and 5 cm pozzolan treatments, respectively, during the first season 2009. The same trends were shown in 2010 (Tables 1-3).

Table 1. Means of the plant height (cm), Leaf area / 5 plants (cm²) under the studied main factors during 2009 and 2010 seasons.

Treatment	Plant height (cm)		Leaf area / 5 plants Cm ²	
	2009	2010	2009	2010
Pozzolan treatment (cm)				
0	54.8 b	42.64 b	2752.14 b	2427.61 b
5	61.81 a	50.96 a	2901.39 a	2558.2 a
Irrigation Intervals (day)				
2	72.99 a	60.23 a	4220.09 a	3722.92 a
4	64.44 b	49.87 b	3394.34 b	2992.86 b
6	53.23 c	40.83 c	2251.62 c	1985.3 c
8	42.57 d	36.27 d	1441.04 d	1270.59 d
Nitrogen fertilization rates (kg/ha)				
50	48.03 d	43.57 c	1960.43 d	1730.54 d
75	52.98 c	44.86 c	2232.96 c	1968.86 c
100	63.96 b	47.56 b	3425.41 b	3020.27 b
125	68.28 a	51.2 a	3688.25 a	3252.02 a
Cultivar				
Black beauty	49.41 c	38.99 c	3344.34 a	2950.26 a
Long purple	55.04 b	47.83 b	2744.49 b	2419.88 b
Topbell	70.48 a	53.58 a	2391.46 c	2108.61 c

* Means followed by the same letter of each trait under each factor are not significantly different according to LSD at P<0.05.

Table 2. Means of the Fruit yield (Kg/ha) and no. of fruits/ plant, under the different main factors during 2009 and 2010 seasons.

Treatment	Fruit yield (Kg/ha)		No of fruits/plant	
	2009	2010	2009	2010
Pozzolan treatment (cm)				
0	22217.68 b	19917.7 b	19.84 b	15.44 b
5	25531.9 a	22702.9 a	28.02 a	25.16 a
Irrigation Intervals (day)				
2	31990.5 a	28519.48 a	30.72 a	25.91 a
4	26284.7 b	23609.13 b	27.18 b	23.42 b
6	20679.9 c	18418.27 c	21.01 c	17.79 c
8	16543.9 d	14734.62 d	16.81 d	14.08 d

Nitrogen fertilization rates (kg/ha)				
50	20153.66 d	18002.1 d	16.45 d	19.6 d
75	22312.74 c	19938.91 c	22.89 c	19.79 c
100	25980.3 b	23211.06 b	25.6 b	20.12 b
125	27052.48 a	24129.41 a	30.77 a	21.7 a
Cultivar				
Black beauty	287773.89 a	27330.39 a	14.56 b	12.38 b
Long purple	25303.06 b	21630.3 b	43.23 a	36.82 a
Topbell	17547.42 c	15000.41 c	13.99 c	11.7 c

* Means followed by the same letter of each trait under each factor are not significantly different according to LSD at $P < 0.05$.

The results indicated that the application of rock mulch with pozollan gave the better performance of plants than the control treatment (without pozollan), and this may be possibility due to irrigation water saving and reduced evaporation rate from soil surface. These results are in agreement with other investigations, Box (1981) and Modiash *et al.*, (1985); Groenevelt *et al.*, (1989); Ossom *et al.*, (2001); Diaz-Perez *et al.*, 2004; Raemarkrishana, 2006; Kittas *et al.*, (2006); Moreno and Moreno (2008); and Dong *et al.*, (2007, 2008, 2009).

Pozzolan significantly improved plant traits (plant height, leaf area/ 5 plants). These results are similar to results of other workers such as karaman and Brohi (1995), Shanging and Unger (2001); Buerkert *et al.*, (2000); and McIntyre *et al.*, (2000). Number of fruits/ plant and yield were also increased by using pozzolan and these were confirmed by Box (1981), Modiash *et al.* (1985) and Groenevelt *et al.* (1989), but pozzolan imposed significance reduction in total soluble solids (TSS) and vitamin C (Table 2).

2- Effect of Irrigation Intervals

Increasing time between the 2 successive irrigations significantly reduced all plant traits. Plant height was reduced from 72.99 at 2 days interval to 42.57 cm at 8 days interval, leaf area /5 plants decreased from 4220.09 to 1441.04 cm²/5 plants, no. of fruits/5 plants from 30.72 to 16.81, and fruit yield/ha from 31990.5 to 1654.9 kg/ ha during the first season. The same effects were showed in the second season but the means were different (Table 1& 2).

Two and four days irrigation intervals were the best for most of fruit yield in the 2 seasons. However, six and eight days irrigation interval treatments induced more water stress on plants under the study.

However, increasing irrigation intervals increased TSS from 2.75 to 3.55, and vitamin C from 4.53 to 5.49 during 2009 season and from 2.5 to 3.31, and from 4.19 during season 2010, (Table 3).

Increasing the irrigation interval reduced yield and the saved water used in plant irrigation, and imposed water stress deficit which caused reduction in plant growth and yield while reducing irrigation interval increased yield and plant traits. These results were similar to Byari (2002) and Al-Shammary (2004).

Table 3. Means of total soluble solid (T.S.S.) and vitamin C of fruit under the studied main factors during 2009 and 2010 seasons.

Treatment	Total soluble solid (T.S.S) (cmg/100).		vitamin C. of fruit.	
	2009	2010	2009	2010
Pozzolan treatment (cm)				
0	2.55 a	3.25 a	5.4 a	5.01 a
5	2.82 b	2.63 b	4.62 b	4.27 b
Irrigation Intervals (day)				
2	2.75 b	2.5 b	4.53 b	4.19 b
4	2.9 b	2.7 b	4.58 b	4.24 b
6	3.55 a	3.32 a	5.43 a	5.03 a
8	3.55 a	3.31 a	5.49 a	5.08 a
Nitrogen fertilization rates (kg/ha)				
50	2.83 c	2.65 c	4.57 c	4.23 c
75	3.01 b	2.81 b	4.92 b	4.56
100	3.44 a	3.21 a	5.26 a	4.87 a
125	3.45 a	3.23 a	5.28 a	4.89 a
Cultivar				
Black beauty	3.25 a	3.04 a	4.95 b	4.59 b
Long purple	3.2 a b	2.99 a b	5.13 a	4.75 a
Topbell	3.1 b	2.8 b	4.94 b	4.58 b

* Means followed by the same letter of each trait under each factor are not significantly different according to LSD at $P < 0.05$.

3. Effect of Nitrogen Fertilizer Rates

Nitrogen fertilizer significantly increased all plant traits compared to control, (50kgN/ha). Plant height significantly increased from 48.03 cm with 50 kg N/ha to 68.28 cm with 125 kg N/ha, leaf area/ 5 plants from 1960.43 to 3688.25 cm², no. of fruits /plant from 16.45 to 30.77 and yield from 20153.66 to 27052.48 kg/ha at 50 and 125 kg N/ha, respectively during the 2009 season. Also fruit yield/ha increased from 18002.1 to 24129.41 kg/ha at 50 and 125 kg N/ha, respectively in 2010 season, N rate increased significantly TSS from 2.83 at 50 kg N/ha to 3.45 Kg N/ha, and fruit vitamin C from 4.57 to 5.28, respectively with increase of

N rate from 50 of to 125 Kg N/ha during 2009 season, and TSS from 2.25 to 3.23, and Vitamin C from 4.23 to 4.89 N rate from 50 to 125 Kg N/ha during the 2010 season. Similar results were found by Byari (1998); Nicklow and Migges (1962); Du *et al.* (1989); Fisher (1971) and Sainju *et al.* (2002).

4- Effect of Eggplant Cultivar

Significant differences were found among eggplant cultivars as regards, no. of fruits/plant, and fruit yield/ha during both seasons 2009 and 2010. The responses of eggplant cultivars were varied. Black beauty cultivar, had lowest no. of fruits/plant and highest yield while Long purple had highest no. of fruits/plant and had acceptable yield/ha, however, top bell produced the lowest yield (Table 1&2).

Conclusions

Irrigation intervals imposed great stress on plants caused some flower drops and reduced the fruit set percentage accordingly and reduced yield of eggplant cultivars, two and four days irrigation intervals had better results in all studied traits. No. of fruits/plant, and fruit yield kg/ha significantly increased as nitrogen fertilizer levels increased. Black beauty cv. was the highest fruits yielding cv. in the experiment.

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تأثير البوزولان والسماذ النيتروجيني في خفض مياه الري والإجهاد الرطوبي للتربة في ثلاث أصناف من الباذنجان

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ص.ب ٨٠٢٠٨ جدة ٢١٥٨٩ - المملكة العربية السعودية

المستخلص. أجريت الدراسة خلال موسمي (٢٠٠٩-٢٠١٠م) لاختبار تأثير استخدام صخر البوزولان، والسماذ النيتروجيني بأربعة مستويات (٥٠، ٧٥، ١٠٠ و ١٢٥ كجم N/للكتار) وأربعة فترات للري (٢، ٤، ٦ و ٨ أيام بين الريه والأخرى) على المحصول ومكوناته والخواص والكيميائية لثلاثة أصناف من محصول الباذنجان الأسود هي (Black beauty, long purple and topbell). وذلك في تصميم القطع المنشقة ثلاثة مرات (Split, Split, Split plot design) في ثلاثة مكررات. أوضحت النتائج إن استخدام صخر البازولان أدى إلى زيادة معنوية في طول النبات، ومساحة الأوراق/نبات وعدد الثمار/نبات والمحصول/هكتار والمواد الصلبة الكلية وفيتامين C في الثمرة مقارنة بعدم التغطية (بدون بوزولان) وأن زيادة فترات الري أدت إلى نقص معنوي في طول النبات، ومساحة الأوراق/نبات عدد الثمار/نبات والمحصول لكنها زادت من المواد الصلبة الكلية وفيتامين C في الثمرة. ولقد أدت زيادة معدلات السماذ النيتروجيني إلى زيادة معنوية في طول النبات ومساحة الأوراق/نبات وعدد الثمار/نبات والمحصول والمواد الصلبة الكلية وفيتامين C في الثمرة. وأعطى

الصنف (Black beauty) أعلى محصول للثمار وذلك راجع إلى زيادة حجم الثمار رغم نقص عددها.

الكلمات الدالة: الباذنجان، البوزولان، النيتروجين، الري، الإجهاد الرطوبي.